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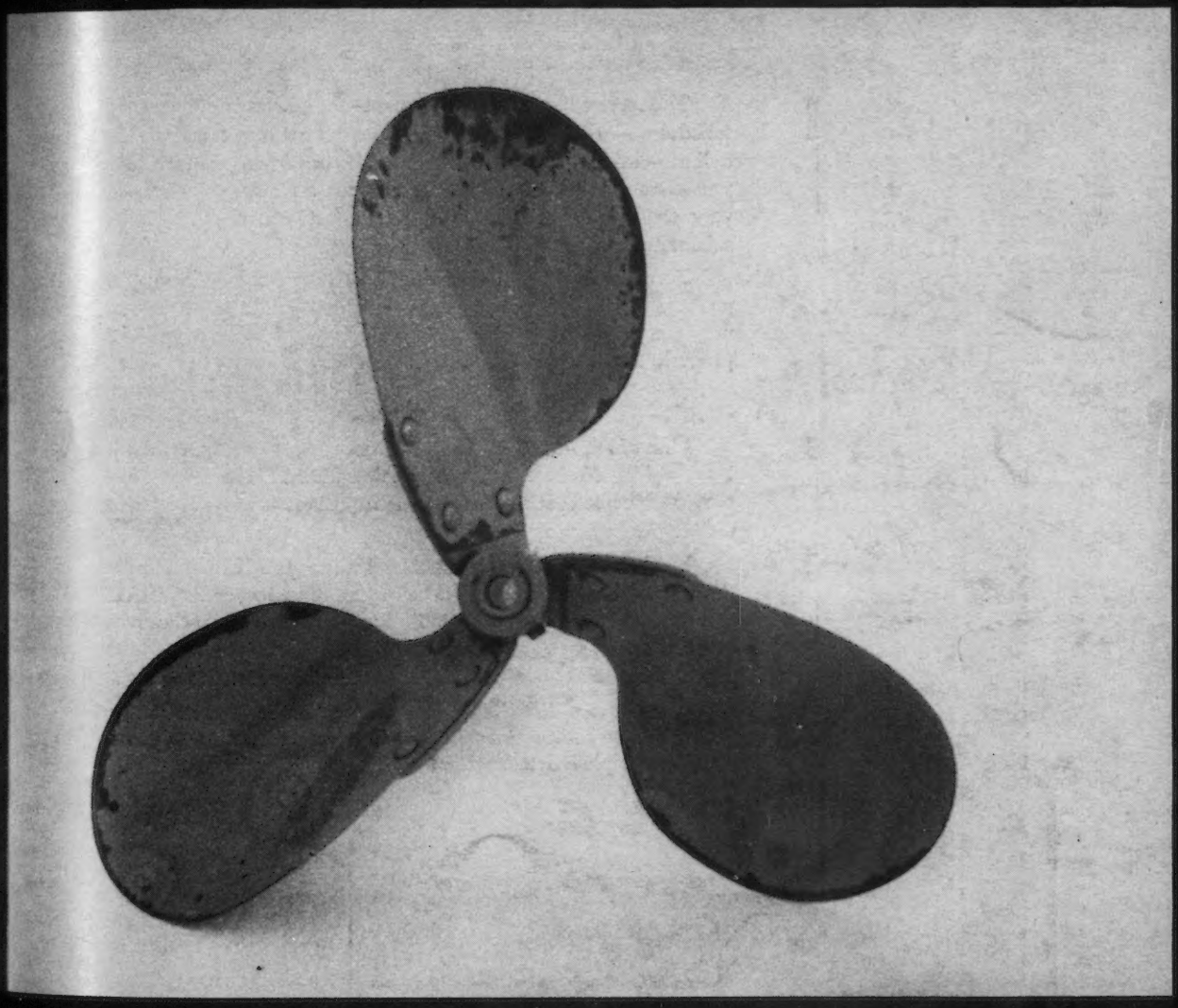

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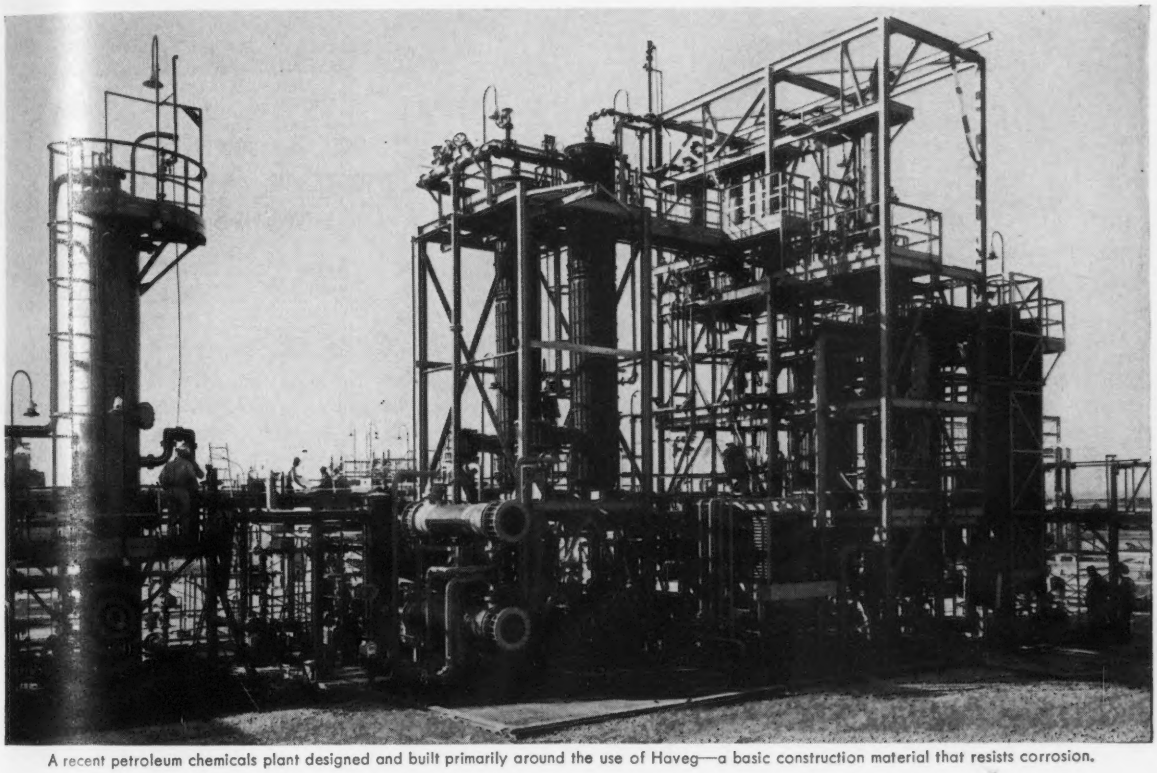

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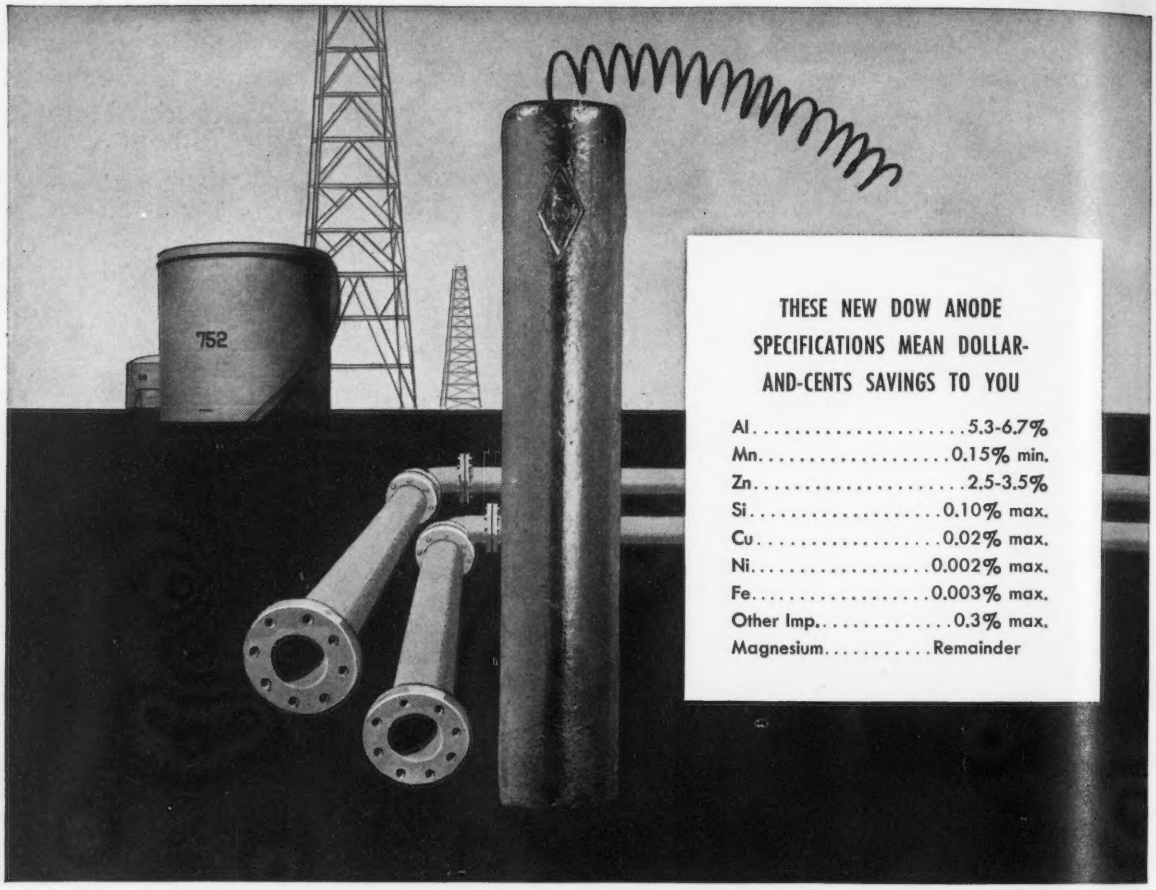

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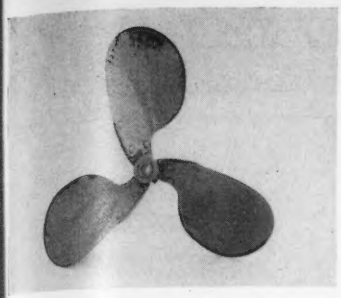

THIS MONTH'S COVER—In less than two seasons' use the leading edges of this steel blade from an electric fan for home use have been stripped of paint and substantially rusted. Dust particles imbedded in lint which attaches itself to the blade edge whip the sprayed-on finish away. No primer coat was visible. Thousands of domestic fans are damaged by corrosion in this way because of inadequate coatings.

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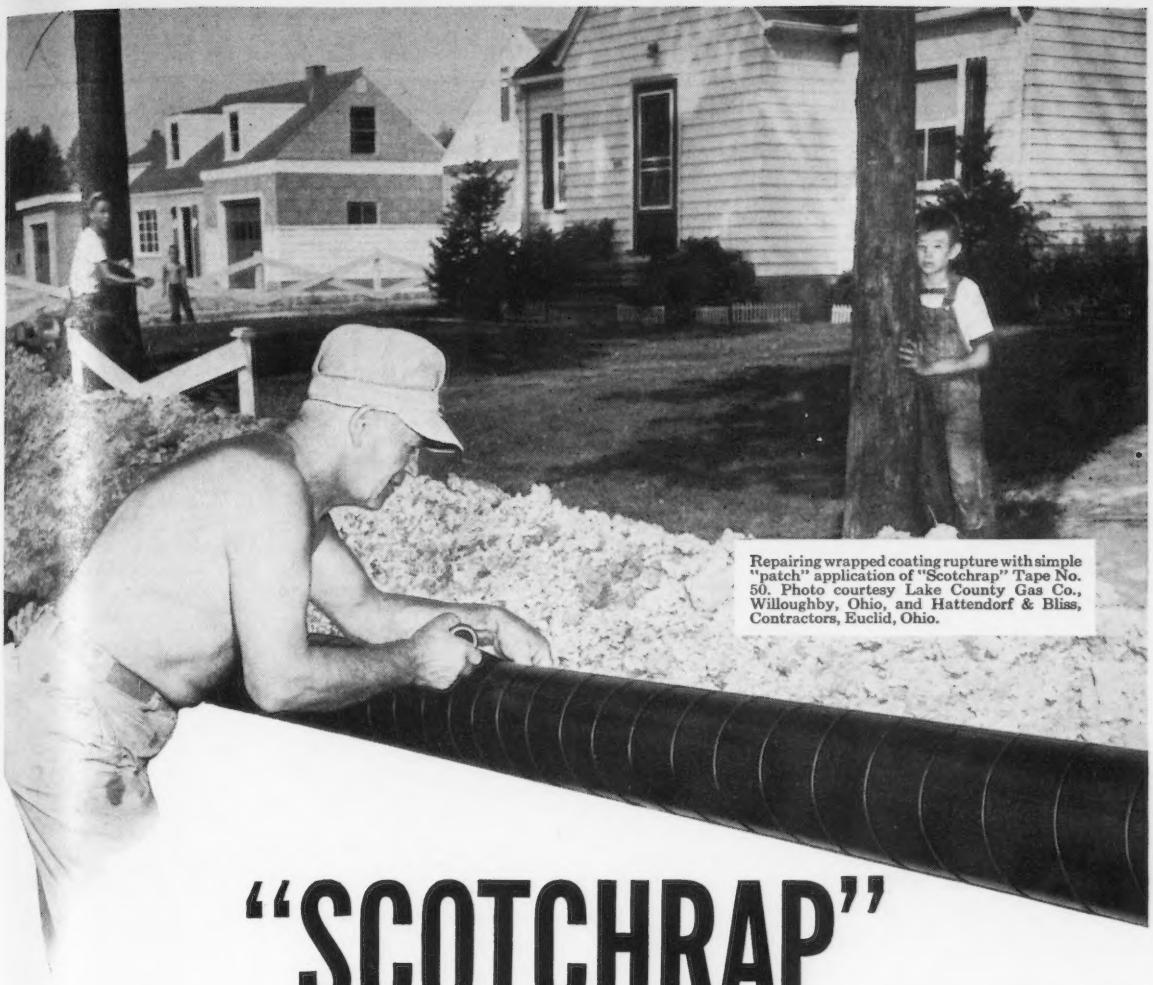

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T-4A Effects of Electrical Grounding on Corrosion

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T-4B Corrosion of Cable Sheaths

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• T-4B-1 Lead and Other Metallic Sheaths

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• T-4B-4 Protection of Pipe Type Cables

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TECHNICAL COMMITTEE NEWS

Turn to the Technical Committee News section in this issue for reports on the latest activities of NACE's technical committees. Officers and members of committees are urged to send in for publication information suitable for this section. Copy deadline is the first of the month preceding the month of issue.

NACE members are urged to call this section to the attention of others interested in corrosion work.

• T-4B-5 Non-Metallic Sheaths and Coatings

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• T-4B-6 Stray Current Electrolysis

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T-4D Corrosion By Deicing Salts

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T-4E Analysis of Domestic Waters

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T-4F Materials Selection for Corrosion Mitigation in the Utility Industry

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T-5A Chemical Industry Manufacturing

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• T-5A-1 Sulfuric Acid

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• T-5A-2 Stress Corrosion Cracking in Alkaline Solutions

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• T-5A-3 Aectic Acid

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• T-5A-4 Chlorine

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• T-5A-5 Nitric Acid

J. L. English, Chairman, Oak Ridge National Laboratory, Box P, Oak Ridge, Tenn.

T-5B High Temperature Corrosion

John Halbig, Chairman, Armco Steel Corp., Middletown, Ohio.

• T-5B-1 Exposure Tests

E. N. Skinner, Chairman, The International Nickel Co., Inc., 67 Wall St., New York, New York

T-5C Corrosion by Cooling Waters

• T-5C-1 Corrosion by Cooling Waters (South Central Region)

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E. L. Haile, Vice Chairman, Monsanto Chemical Co., Box 1311, Texas City, Texas.

R. H. Maurer, Secretary, Celanese Corp., Box 148, Bishop, Texas.

T-5D Plastic Materials of Construction

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T-6 Protective Coatings

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L. L. Whiteneck, Vice Chairman, Long Beach Harbor Dept., 1333 El Embarcadero, Long Beach 2, California

T-6A Organic Coatings And Linings For Resistance To Chemical Corrosion

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C. G. Munger, Vice Chairman, Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif.

J. J. Ondrejoin, Secretary, E. I. DuPont de Nemours & Co., Inc., Polychemicals Dept., Wilmington, Delaware.

T-6B Protective Coatings for Resistance to Atmospheric Corrosion

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Howard C. Dick, Vice Chairman, Products Research Service, Inc., Box 6116, New Orleans, Louisiana

T-6C Protective Coatings for Resistance to Marine Corrosion

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• T-6C-1 Protective Coatings for Resistance to Marine Corrosion (Pacific Coast Region)

T-6E Protective Coatings in Petroleum Production

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T-6G Surface Preparation For Organic Coatings

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S. C. Frye, Vice Chairman, Research Dept., Bethlehem Steel Co., Bethlehem, Pa.

T-6H Glass Linings And Vitreous Enamels

G. H. McIntyre, Chairman, Ferro-Enamel Corp., Harvard & 56th Street, Cleveland 5, Ohio

T-6K Corrosion Resistant Construction With Masonry And Allied Materials

Robert R. Pierce, Chairman, Pennsylvania Salt Manufacturing Co., 1000 Widener Bldg., Philadelphia, Pa.

• T-6L-1 Asphalt Type Coatings (Pacific Coast Region)

T-6M Field Coating Inspection

L. L. Whiteneck, Chairman, Long Beach Harbor Dept., 1333 El Embarcadero, Long Beach 2, California.

• T-6M-1 Field Coating Inspection (Pacific Coast Region)

T-6R Protective Coatings Research

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Permits high speed wrapping . . . assures effective protection for enamels

TRANSHIELD now offers pipe line men the fine protective qualities of an asbestos shield at a lower price . . . with the added advantage of improved application characteristics. Transhield is a quality felt . . . assuring long trouble-free service. It is designed to meet all ordinary wrapping needs.

Transhield provides a continuous asbestos membrane, protecting and preserving the enamel coating. Highly resistant to soil stress, it is particularly suitable for use where pipe must be laid in heavy clay soils. It cannot rot or decay . . . presents an almost indestructible barrier against soil chemicals.

Contractors like Transhield because its special reinforcement makes it easy to apply, even at high speeds. Embedded continuous glass yarns parallel-spaced on ¼" centers give Transhield unequaled tear resistance. Transhield's light weight permits furnishing it in 800-ft. rolls. This advantage cuts roll changes in half for field wrapping equipment.

Johns-Manville has developed three wrapping materials for pipe line protection:

J-M 15-lb. Asbestos Pipe Line Felt (perforated or unperforated)—for severe soil conditions.

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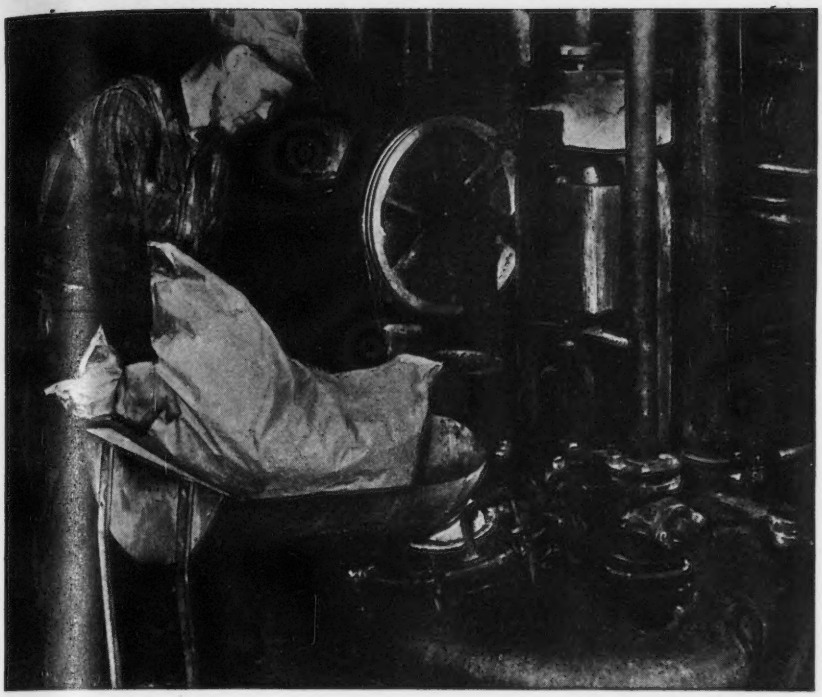
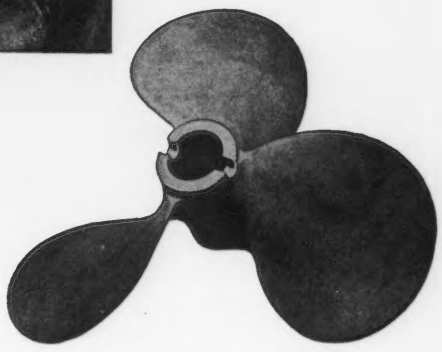


Trouble-Free Production of Intermediates by Zinsser and Company, attests to the exceptional corrosion resistance of propellers, shafts, thermometer wells and blow-off lines fabricated from one of the high nickel-base alloys trade-named "Hastelloy," produced by Haynes Stellite Company, Kokomo, Indiana, a Division of Union Carbide and Carbon Corporation.

Still Good After 5 Years

in Hot H_2SO_4 and HCl



High Nickel-Base Alloy Cuts Maintenance. This propeller, made from HASTELLOY alloy D, is still in use after five years . . . mastering corrosion that caused propellers made from other materials to fall off and chip the kettle lining. Repairing kettles and replacing propellers were expensive maintenance items, heretofore.

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Zinsser uses a process that involves adding various aromatic organic chemicals, some of which contain chlorine, to a solution containing sulphuric acid. Since the solution is held in several 500-gallon kettles which are heated to 200° C., severely corrosive conditions arise from the resulting hydrogen chloride gas formed at this high temperature.

Nevertheless, a high nickel-base alloy . . . trade-named HASTELLOY alloy D . . . solves this particular problem, just as it has solved many others where exceptional corrosion resistance is needed at high temperatures.

Prior to using HASTELLOY alloy D, Zinsser found that equipment had to be replaced about every three months. Various materials were tried, but no improvement resulted until the high nickel alloy was put into service more than five years ago. And . . . it is still in use, reducing maintenance costs.

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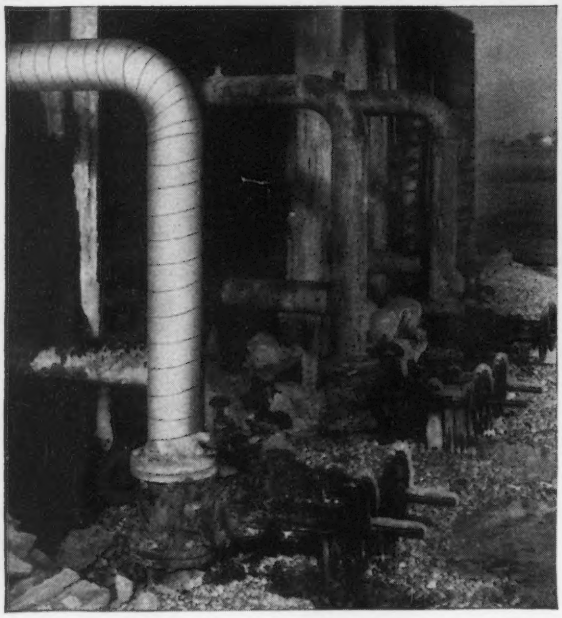
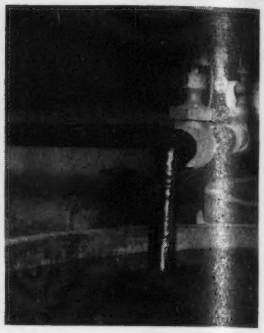
Polyken TAPE GIVES BETTER CORROSION PROTECTION



❶ **On Michigan-Wisconsin Pipe Line Co.** cooling tower, *Polyken* protected pipe on left has outlasted pipes on right 3 to 1 with no sign of wear.

❷ **Hoffman and Jacobs,** Long Beach, California, coat underground conduits faster, easier, and more economically with a single wrap of *Polyken* tape.



❸ **In plants** where direct chemical attack causes corrosion, *Polyken* polyethylene tape coatings prove their superior corrosion-resistant qualities.

❶ *Above ground* where age, temperature and atmosphere are the destructive corrosive elements.

❷ *Under ground* where protection is needed against electrolytic and chemical attack in addition to bacterial and fungus growth.

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Resists external corrosive forces in all types of pipe installations

Polyken tapes are the new, proven method to fight corrosion. In actual tests both in the laboratory and in the field, *Polyken* tapes outperform other protective coatings on many types of jobs . . . and here's why:

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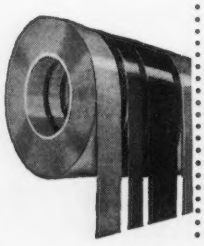

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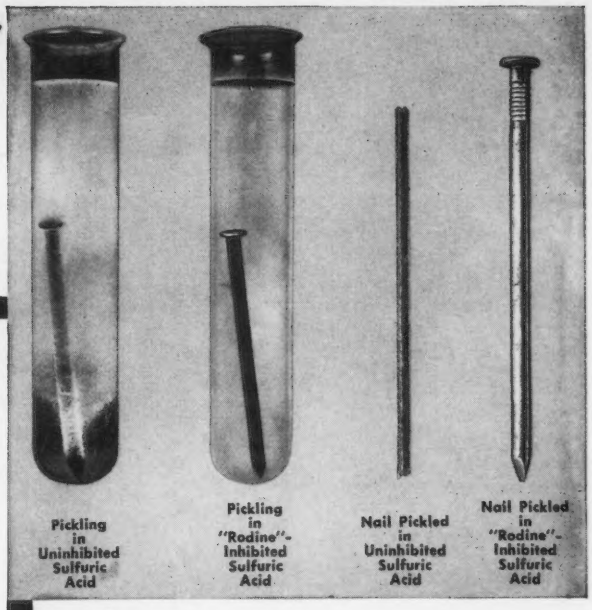
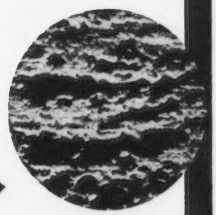

Pickling in Uninhibited Sulfuric Acid
Pickling in "Rodine"-Inhibited Sulfuric Acid
Nail Pickled in Uninhibited Sulfuric Acid
Nail Pickled in "Rodine"-Inhibited Sulfuric Acid

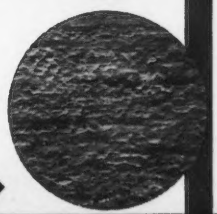
The photographs above illustrate the beneficial effect produced by a small amount of "Rodine" in a pickle bath.

A. Both test tubes contain a 10 per cent by volume solution of sulfuric acid. In the left-hand tube, no further additions have been made to the acid. Notice the gas bubbling off the nail. This is hydrogen, caused by the action of acid on good metal. In the right-hand tube, "Rodine" has been added in an amount equal to 1 per cent by volume of the concentrated acid. Notice the absence of bubbling in this tube. "Rodine" prevents the formation of hydrogen that results from dissolving metal.

B. Both nails after being pickled for the same time. The nail pickled with "Rodine" has lost little weight and has retained its original luster and appearance. The nail pickled without "Rodine" is no longer a nail. "Rodine" prevents the acid from dissolving metal.



This steel surface was pickled in an uninhibited acid bath. Note the deep pits, and that the surface is visibly crystalline.



This surface was pickled exactly like the one above except that "RODINE" was added to the acid solution. Only scale pockets and roll marks are visible; no pitting occurred.

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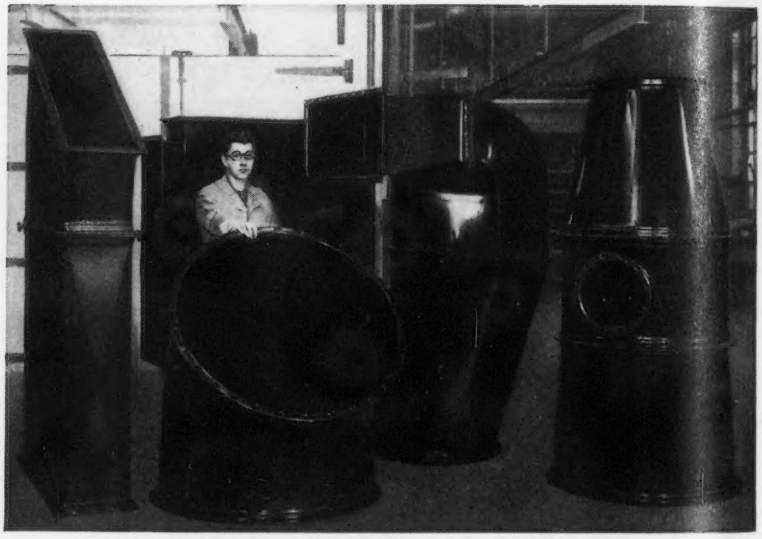
News about
COATINGS for METALS
Metallic . . . . . Organic . . . . . Decorative . . . . . Protective

New corrosion-control "tool" provided by spraying-type plastisol

Unichrome Series 5300 Plastisols protect equipment with single coats up to 25 mils thick



These fume control ducts, better equipped to resist corrosion, typify the large areas which can now be protected with Unichrome Plastisols.

ANY metal surface that can be sprayed and uniformly baked can now be protected against severe corrosive conditions with vinyl plastisol. Development of Unichrome Series 5300 Plastisols, the first practical sprayable plastisols, offers engineers the solution to many chemical corrosion problems.

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Unichrome Series 5300 Plastisols have many advantages over ordinary coatings. They offer continuous, seam-and pore-free protection against a wide variety of corrosives, including acids, alkalies, water, salt solutions, oxidants, reducing agents, and many others. They level surface irregularities and provide substantially greater protective film thickness, features particularly important in coating surfaces that are not smooth. 5300 Plastisols are resilient, resist abrasion, chipping and cracking. Single coat dry film thicknesses up to 25 mils can be obtained.

ASSISTANCE IN SOLVING PROBLEMS

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A variety of Ucilon* Protective Coating Systems, using either air-drying or baking coatings are available to handle problems that cannot be solved with plastisols. Applied like ordinary paint, Ucilon Coating Systems resist the same corrosives as plastisols and even some that plastisols do not withstand. The line includes systems based on vinyl, phenolic, chlorinated rubber and other chemical resisting coatings. Detailed information is provided in Bulletin MC-8. Send for it—no obligation.

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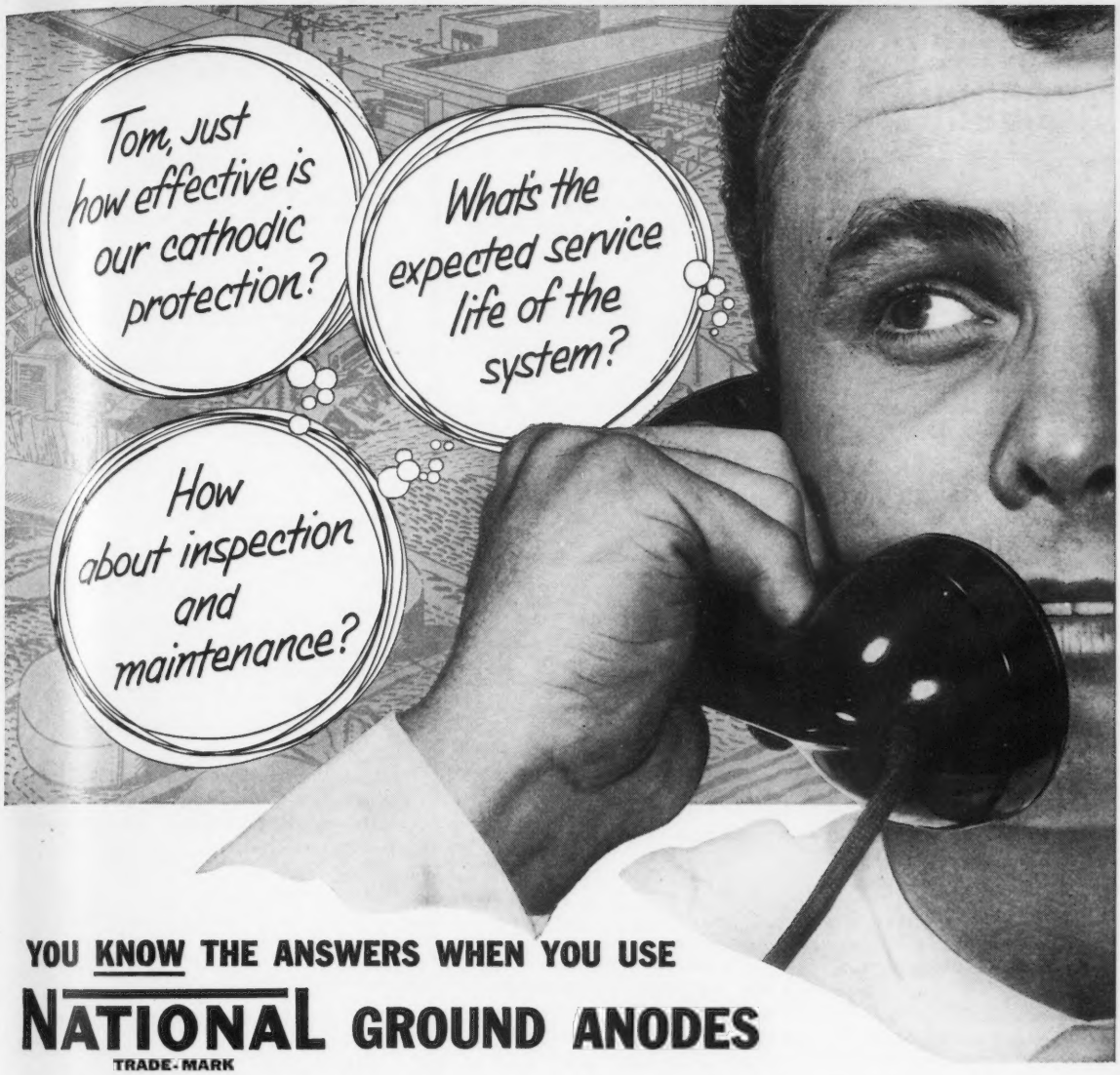
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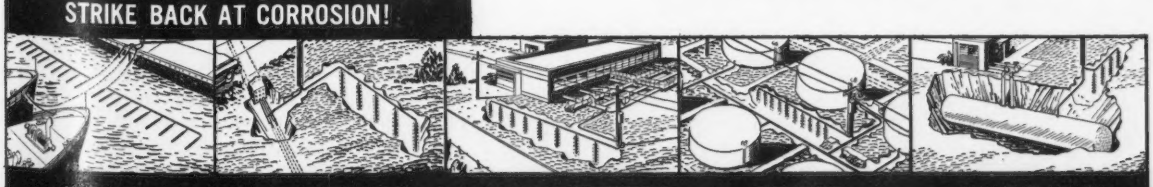

THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

(a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.

(b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.

(c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.

(d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.

(e) To promote standardization of terminology, techniques, equipment and design in corrosion control.

(f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.

(g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.

(h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 1061 M & M Building, No. 1 Main Street, Houston 2, Texas.

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Corrosion

OFFICIAL MONTHLY PUBLICATION

National Association of Corrosion Engineers

An Association of Individuals and Organizations Concerned with Control of Corrosion

1061 M & M Building Houston 2, Texas

Vol. 10 June, 1954 No. 6

Technical Committee News Section Will Keep Members Informed

By H. W. SCHMIDT*

THERE has long been a need for keeping NACE membership better informed on Technical Committee activities. In the past, stories have appeared among items of general interest in the news section of Corrosion magazine. Most were concerned with election of officers and other similar matters.

Beginning with the May issue of Corrosion a Technical Committee News section was inaugurated. This section contains accounts of the activities of the various committees. Formation of new committees and their purpose will be announced. Progress of the work of older groups will be followed. Problems that have been discussed will be presented. An especial effort will be made to present briefly points of interest that arise in committee work. Developments in committee reports will be followed and presented.

The present issue contains several stories about the activities of some of the committees and is indicative of the kind of material to be carried. An abstract of a proposed standard method of measuring electrical conductance of coatings on buried pipe lines prepared by Committee T-2D is presented. Some of the work of T-1B on the use of organic inhibitors in oil and gas wells is reported. Some problems concerning cathodic protection of cable sheaths being studied by T-4B-2 are reviewed. A study of some aspects of corrosion in sweet oil wells by T-1C is discussed.

The purpose of the new section is to briefly outline the kinds of work the committees are doing, what progress is being made on the various projects, and informally indicate what methods have been found to be effective in mitigating corrosion. Usually a considerable time elapses between the completion of an investigation and the time a formal report can be issued. Developments on the project can be summarized periodically in this section during this interval. Many times interesting observations on some problem are presented to a committee but, due to their nature they may be filed in the minutes of the meeting and never reported formally by the committee. These items are ideal material for the Technical Committee News section.

Assistance from members of all technical committees will be needed if this new section is to be successful. Material for stories may be forwarded to NACE Central Office by chairmen. Another source of material will be the minutes of meetings. All stories prepared for the news section will be submitted to the chairman of the particular committee affected for his approval. If a chairman for some reason does not desire publicity he is free to request that the story be withheld.

The section also may serve to announce future committee meetings. In this case it must be remembered that for an announcement to appear to advantage in Corrosion, information about the meeting must be in Central Office by the first of the month preceding the month of issue. For example, the deadline for the June issue was May first.

Since the annual conference in Kansas City, two changes in committee organization have been made. Two committees concerned with pipe line coatings, T-6D on Coal Tar Coatings and T-6L on Asphalt Coatings have been shifted from the Protective Coatings group to the Pipe Line group and designated as T-2G and T-2H, respectively. A new committee on Wrappers has been approved and designated as T-2J. It was felt that this change was desirable to concentrate all work on pipe lines in Committee T-2.

Interest in cathodic protection has been expanded. Committees T-2A, T-2B, T-2C and T-2D will restrict their activities on cathodic protection to pipe line matters only. A new committee T-3G is being formed to consider the problems of cathodic protection applied to all other structures except pipe lines. It is believed there is sufficient activity in these fields to warrant establishment of the committee.

* The Dow Chemical Co., Midland, Mich., chairman Technical Practices Committee.

Effect of Alloying and Impurity Elements In Magnesium Alloy Cast Anodes*

By H. A. ROBINSON* and P. F. GEORGE*

WHEN MAGNESIUM anodes were introduced, it was generally assumed that composition specifications governing impurity limits could be based on the salt water corrosion data reported by Hanawalt, Nelson and Peloubet.[1] It soon became evident, however, that impurity levels consistent with good salt water corrosion resistance could not always be relied upon to give satisfactory anode efficiencies. Various reasons for this can be assigned. In salt water exposure of a non-galvanic nature, the action of exposed cathodic impurities is gradually reduced by a combination of cathodic polarization and excision of the impurity particle by corrosion attack along its boundaries. The net result is that corrosion rate tends to fall off markedly with time to some lower and equilibrium level. In contrast, when magnesium corrodes as a galvanic anode, protective film formation is inhibited and fresh impurity particles are continuously being exposed so that opportunities for polarization of local cathodes are distinctly less favorable. As a consequence local corrosion rates are markedly higher than the corresponding non-galvanic rates and could be expected to show greater sensitivity to the various cathodic impurities.

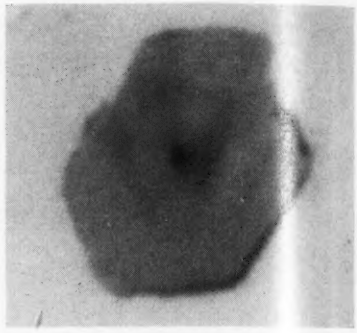

Figure 3—Photomicrograph of a manganese particle (dark gray) surrounding a small iron particle (black) in AZ63 alloy. X 6000.

Abstract

Data from extensive laboratory anode efficiency tests and supporting field tests illustrate the need for low impurity levels in the 6% Al—3% Zn magnesium alloy cast anodes. Data are presented which show the detrimental effects of the impurities copper, nickel, iron, lead and tin; the beneficial effect of manganese in counteracting to some extent the effects of iron and perhaps copper; the absence of any pronounced effect of aluminum and zinc in the amounts specified in this alloy; and the inertness of small additions of beryllium on the anode efficiency.

In recent years the need for a restudy of impurity tolerances in magnesium alloy anodes has been further enlivened by the desirability of using scrap or secondary metal in anode manufacture. In general, this poses the problem of higher levels of some but not all impurities and of writing composition specifications which will accommodate these higher impurity levels with a minimum sacrifice of anode performance. Although magnesium anodes currently are being sold under at least three different composition specifications (see Table 1), little if any published data characterizing the performance to be expected from these various compositions have been made available, apart from the work undertaken by Committee TP-2 of the National Association of Corrosion Engineers (now T-2) and the early work reported by The Dow Chemical Company. Obviously a restudy of impurity tolerances is desirable if appropriate specifications are to be drawn covering the various grades of metal available to the industry. Such studies afford both producer and consumer greater assurance of a uniform product and may even enable the producer to utilize a grade of metal which otherwise would fail to meet anode performance requirements (e.g., iron and copper tolerances can be improved somewhat by carrying a suitably high manganese level).

The data of this paper are drawn from some 1200 individual anode efficiency tests and comprise the results obtained on over 120 different melts of the Mg—6% Al—3% Zn type alloy. Most of the data reported were obtained with the laboratory pencil test although supporting field test data also are presented. Pencil test results have in the past correlated well with field experience and this test has the definite advantages of greater speed, accuracy and reproducibility as compared to field testing where variables such as anode current density, soil resistivity, temperature and the like are difficult to control.

Accumulation of Data Presented

Materials conforming to all of the specifications listed in Table 1 have been tested and an effort has been made to isolate the effect of a given impurity or alloying element by examining the results from compositions in which only that element varied to a significant degree. Apart from some work on the iron-manganese and copper-manganese interactions,

★ A paper presented at a meeting of South Central Region, National Association of Corrosion Engineers, October 7-9, 1953.

* Metallurgical Laboratories, The Dow Chemical Company, Midland, Mich.

no attempt has been made to study interactions between impurities or the effects of various combinations of impurities. The latter is in itself a major undertaking and its execution will require the cooperative efforts of all anode producers. Likewise, the entire ranges of composition afforded by the various specifications have not been fully explored. Thus, this paper does not pretend to be in any sense a complete exposition on the effects of impurities. Rather it is intended to present an accumulation of new data pertinent to the general problem of understanding and wherever possible, controlling the effects of impurities on anode performance.

Results are reported wholly in terms of the effect of the impurity on anode efficiency, since, apart from anode potential, this is the property most directly affecting the cost of the current derived from the anode installation as well as the pocket book of the customer. The costs of delivered current increase at a surprisingly rapid rate with decrease in anode efficiency because installation costs remain uniform irrespective of the efficiency of the anode metal used. Thus if installation cost of $0.50 per hundred is assumed, metal supplying 450 ampere-hours per pound would have to be priced at $0.40 per pound in order to deliver current at the same cost as metal supplying 500 ampere-hours per pound and priced at $0.50 per pound.

Anode potential is also a highly significant cost factor because it determines the number of installations needed to supply a given amount of current. Data on potentials have not been presented largely because the impurity concentrations under consideration have not been high enough to appreciably affect anode potentials.

Two Current Densities Reported

To a considerable extent anode efficiencies have been reported only for the 36 and 72 milliampere per square foot current densities since these correspond most closely to the current densities encountered in actual underground service. In some cases impurity effects are shown for a rather wide range of current density, these data illustrating the pronounced dependence of impurity effects upon anode current density. Thus, an impurity level which has a highly adverse effect on efficiency at the lowest current densities may be tolerated readily if the anode is allowed to operate at a high current density.

Testing Procedure

The pencil testing procedure employed is essentially the same as that previously described by Robinson,[2] recent improvements to this test method being only minor alterations concerned with the mounting of the test specimen. Anode test materials were taken both from 17-pound production anodes of known composition and from special test bars cast from alloy melts to which the various impurities had been added in controlled amounts.

TABLE 1

Composition Specifications for Cast Magnesium Anodes of the 6% Al, 3% Zn Type Alloy

	A	B	C
Al	5.3—6.7	5.3—6.7	5.0—7.0
Zn	2.5—3.5	2.5—3.5	2.0—4.0
Mn	0.15 Min.	0.15 Min.	0.10 Min.
Fe	.003 Max.	.003 Max.	.003 Max.
Ni	.002 Max.	.003 Max.	.003 Max.
Cu	.02 Max.	.05 Max.	.10 Max.
Si	.10 Max.	.30 Max.	.30 Max.

The test electrolytes used were 1) a saturated $CaSO_4$ solution and 2) 3% NaCl solution, the former providing test conditions comparable to those of a gypsum backfill and the latter simulating a saline electrolyte. The current densities employed ranged from 7.2 to 360 miliamperes per square foot, these limits corresponding approximately to current flows of 15 and 720 milliamperes respectively from a 17-pound anode. The test duration was 14 days as previously described.[2]

Because of the microporosity occasionally found in production anodes, care was taken to thoroughly dry the anode pencils after testing and cleaning by holding at 225-350 F in an oven over night. Failure to do so may lead to the weighing of absorbed water with the result that erroneously high anode efficiencies (70-80%) are reported.

Field tests were carried out in the manner previously described by Osborn and Robinson.[3] Seventeen-pound production anodes conforming to the various specifications listed in Table 1 were placed on test in both low (50-100 ohm-cm) and high (500-1000 ohm-cm) resistivity soils at the Freeport, Texas, test site. These anodes were installed in the 3B1G1Na (bentonite-gypsum-sodium sulfate) backfill at about a six-foot depth and current flows were controlled by the use of resistors to give a narrow range of current density and thereby permit fair comparisons. Current flow ranges of 100-150 and 66-100 milliamperes were maintained in the low and high resistance soils, respectively. The data presented here are for anodes removed after twelve months of testing.

Results

The effect of each element, as shown by the following curves, was obtained by selecting a series of alloy compositions which varied substantially in only one element. This one element was then plotted against the anode efficiency determined at a given anode current density. Each point on the curves represents an average of at least two and sometimes as many as ten determinations.

Effect of Aluminum

By selecting compositions that varied only in aluminum, the curve shown in Figure 1 was obtained. Only one melt was on hand that would give a point below 6% aluminum. Although the curve does indicate a slight advantage with alloys with the aluminum in the higher range, it would be safer to conclude that aluminum in the range usually found in this alloy has little if any effect on the anode efficiency. All the anode efficiency data in this curve were obtained in a saturated $CaSO_4$ electrolyte at an anode current density of 36 milliamperes per square foot. This is equivalent to about 72 milliamperes of current from a 17-pound anode.

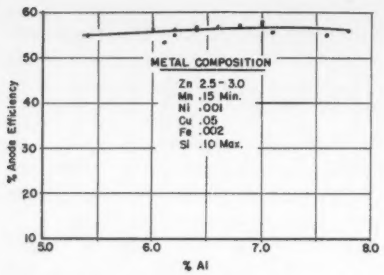

Figure 1—Effect of aluminum.
Electrolyte: Saturated $CaSO_4$.
Current density: 36 ma/sq. ft.

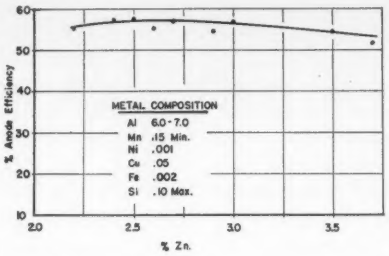

Figure 2—Effect on zinc.
Electrolyte: Saturated $CaSO_4$.
Current density: 36 ma/sq. ft.

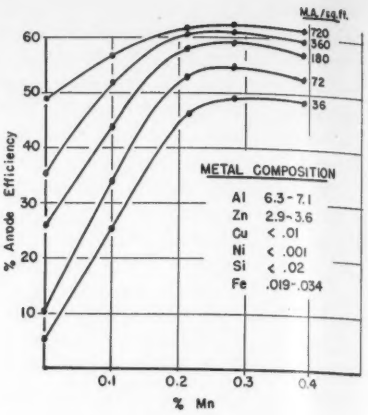

Figure 4—Effect of manganese with high iron.
Electrolyte: Saturated $CaSO_4$.
Various current densities.

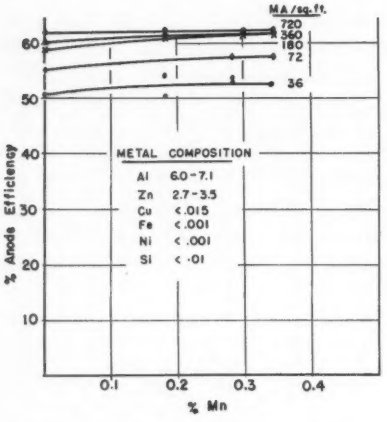

Figure 5—Effect of manganese with low iron.
Electrolyte: Saturated $CaSO_4$.
Various current densities.

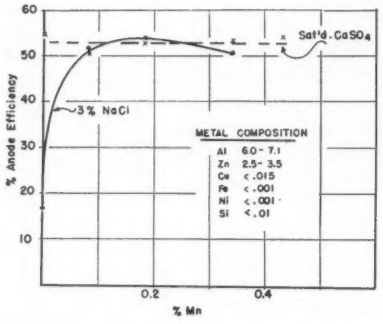

Figure 6—Effect of manganese in two electrolytes.
Current density: 72 ma/sq. ft.

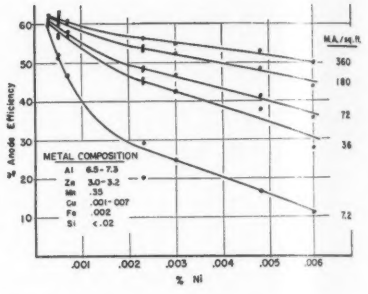

Figure 7—Effect of nickel.
Electrolyte: Saturated $CaSO_4$.
Various current densities.

Effect of Zinc

The effect of zinc in the alloy on the anode efficiency is shown in Figure 2. The data show a slight drop in anode efficiency with the higher range of zinc. But here again, with only two points above 3% zinc, it is safe to conclude that zinc in the range specified in this alloy has little effect on the anode efficiency.

Effect of Manganese

It has long been known that manganese is a scavenger element having high utility in magnesium alloying for control of the effects of impurities, especially iron. Manganese counteracts iron in at least two ways: 1) It lowers the iron content of the metal by settling iron from the melt and 2) during solidification, it surrounds iron particles left in the metal making them inactive as local cathodes. Figure 3 shows a photomicrograph of an iron particle embedded in a manganese particle. By this solidification mechanism manganese replaces the iron as the effective local cathode. The potential difference between the manganese particle and the magnesium has been shown to be much less than between the iron particle and the magnesium. Manganese, therefore, produces a very desirable effect and this effect is shown to be more pronounced when the iron is high. Figure 4 shows the effect of manganese on the anode efficiency of metal containing 0.02 to 0.035% iron, while Figure 5 shows the effect of manganese on metal very low in iron.

When the metal contains less than .001% iron, manganese additions improve the cathode efficiency only slightly in the $CaSO_4$ electrolyte. However, manganese additions to the low iron metal show a marked improvement in the 3% NaCl electrolyte. This is illustrated in Figure 6 and indicates that manganese is necessary in low iron metal for saline applications.

The effect of manganese on the anode efficiency also depends to some extent on the amount of copper in the alloy. This is shown in Figure 10 and will be discussed later under the effect of copper.

It can be concluded that manganese is essential in this alloy for good dependable anode efficiency. True, if the iron and copper were kept very low and the anodes were not used in a saline electrolyte, good efficiencies would be expected. But because none of these factors can be entirely relied upon, manganese becomes a very important alloying element.

Effect of Nickel

The work of Hanawalt et al[1] on the salt water corrosion resistance of alloys approximating the

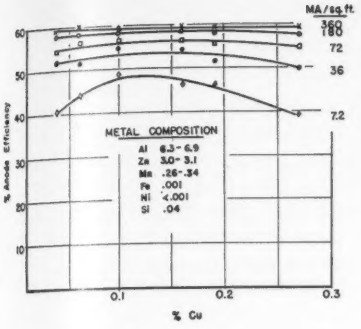

Figure 8—Effect of copper. High manganese—low impurities.
Electrolyte: Saturated $CaSO_4$.

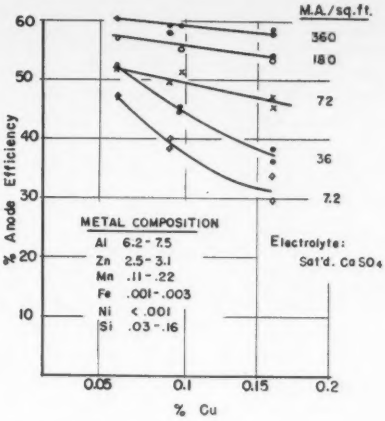

Figure 9—Effect of copper.
Various current densities.

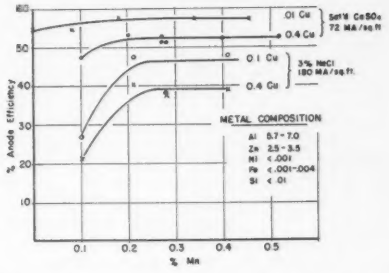

Figure 10—Effect of manganese at various copper levels.

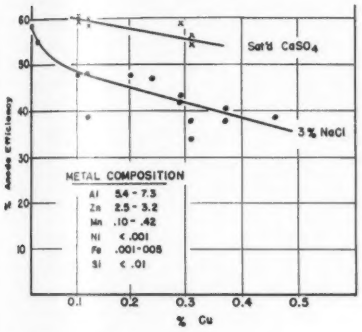

Figure 11—Effect of copper.
Current density. 180 ma/sq. ft.

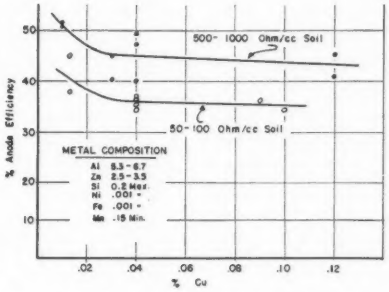

Figure 12—Effect of copper. Field tests at Freeport, Texas.

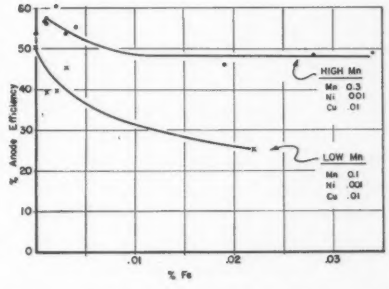

Figure 13—Effect of iron at two manganese levels.
Electrolyte: Saturated $CaSO_4$.
Current density: 36 ma/sq. ft.

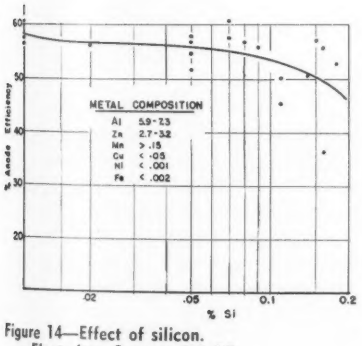

Figure 14—Effect of silicon.
Electrolyte: Saturated $CaSO_4$.
Current density: 36 ma/sq. ft.

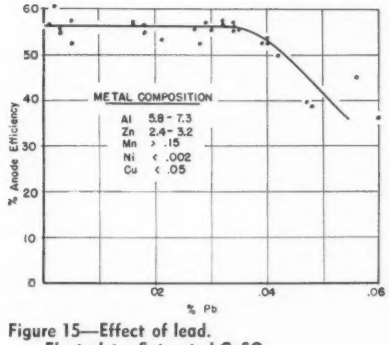

Figure 15—Effect of lead.
Electrolyte: Saturated $CaSO_4$.
Current density: 36 ma/sq. ft.

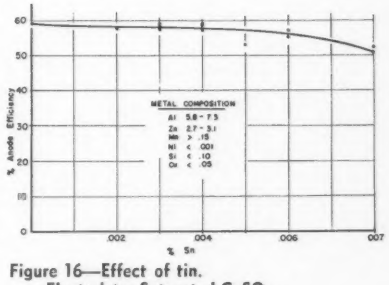

Figure 16—Effect of tin.
Electrolyte: Saturated $CaSO_4$.
Current density: 36 ma/sq. ft.

Mg—6% Al—3% Zn composition indicated that nickel was well tolerated up to about .003% at which point corrosion rates broke upward sharply to substantially higher levels. Evidence indicating that this limit might not be wholly satisfactory for anodes was first observed in a comparison of three different lots of production anodes having the compositions and efficiencies listed in Table 2.

The poor performance of Lot 3 was striking and might have been attributed to its generally higher impurity level (Cu, Ni and Si) but for the fact that the copper and silicon levels were very close to those of Lot 2 which gave good performance. This strongly implicated nickel, although it was well within existing specification limits and led to a series of tests in which controlled amounts of nickel were added to high purity alloy melts.

The results of the first pencil test showed a pronounced effect of nickel at concentrations well below the existing .003% limit. These results were so unexpected that a second melt covering the same nickel

TABLE 2
Anode Efficiency and Composition of Three Lots of Production Anodes

Lot No.	Percent Al	Percent Cu	Percent Fe	Percent Mn	Percent Ni	Percent Si	Percent Zn	PERCENT ANODE EFFICIENCY $CaSO_4$	PERCENT ANODE EFFICIENCY Backfill
1.....	7.4	.028	<.001	.16	<.001	.002	3.1	57.	62
2.....	6.6	.071	<.001	.22	<.001	.10	3.2	59.6	60.5
3.....	7.0	.07	<.001	.22	.0023	.09	3.0	41.8	39.8

Efficiency values listed are the average of at least four determinations, the agreement between individual samples being good. Anode current density was 72 M.A./sq. ft.

TABLE 3
Effect of the Manganese-Copper Ratio on the Anode Efficiency of Magnesium Alloy Anodes
Saturated $CaSO_4$

Percent Cu	Percent Si	Percent Mn	Percent Fe	Percent Ni	Mn/Cu Ratio	PERCENT ANODE EFFICIENCY C.D.M.A./Sq.Ft. 36	72
.052	.03	.22	<.003	<.001	4.7	52.3	51.0
.096	.11	.16	<.003	<.001	1.7	45.2	51.8
.088	.08	.13	<.003	<.001	1.5	39.8	49.6
.160	.11	.15	<.003	<.001	0.94	36.1	47.1
.160	.16	.11	<.003	<.001	0.69	38.8	45.3

range was prepared and the test was repeated with essentially the same result. The combined data from both tests are shown in Figure 7. In general, these data show significant improvement in anode efficiency down to very low nickel levels and indicate that, for the current densities prevailing in underground service, nickel should not exceed .002% if efficiencies are to be maintained at or above 50%.

Effect of Copper

The effect of copper on anode efficiency has been and may well continue to be controversial insofar as its effect could easily depend on the presence or absence of other impurities. Data strongly indicating that copper tolerance is dependent upon manganese content will be presented by this paper. It is further observed that high copper contents are commonly associated with a comparatively high background of other impurities notably silicon, and, in some instances, tin or lead. The effects of these associated impurities on copper tolerance are not known but it appears more than coincidental that the adverse effects of copper are frequently observed in material carrying a high level of one or more of these impurities.

Salt water corrosion data would indicate that copper is well tolerated by pure magnesium at levels as high as 0.13%. Early studies of the effect on anode efficiency of copper additions to high purity alloy melts, high in manganese, produced the results presented in Figure 8. At the lower current densities these data actually indicate a beneficial effect of copper at levels up to about 0.15%, beyond which anode performance again falls off.

Succeeding investigations of production-scale compositions, variable with respect to copper, manganese and silicon, produced the data shown in Figure 9. Here copper exhibits a pronounced detrimental effect, anode efficiencies falling off sharply with increasing

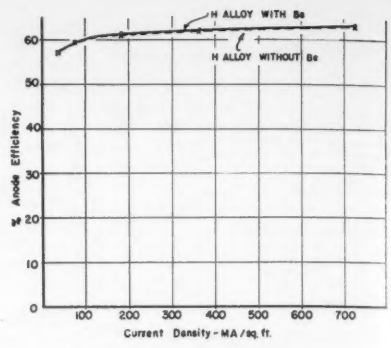

Figure 17—Effect of beryllium. Electrolyte: Saturated $CaSO_4$.

copper especially at low current densities. It is noteworthy, however, that the silicon content of this material paralleled the copper content quite closely and that a further analysis of the data disclosed an apparent correlation between efficiency and the Mn/Cu ratio as illustrated in Table 3.

While these data only hint at a possible dependence of copper tolerance on manganese content, they are further and more firmly supported by the data presented in Figure 10. This graph illustrates the results from tests on high purity melts containing variable amounts of copper and manganese and indicates that the efficiency of compositions high in copper falls off rapidly when manganese drops below about 0.2%, especially in salt water service. This drop in efficiency at low manganese levels seems definitely attributable to copper since for high purity alloys low in copper, efficiencies fall off sharply only at manganese levels well below 0.1% Mn (Figure 6).

Evidence that copper can detrimentally affect the efficiency of the alloy, even at relatively high manganese and low silicon concentrations, is seen in Figure 11. Although the composition listed shows a manganese range of 0.10-0.42% manganese levels below 0.2% were confined to the three composition points containing 0.1% copper or less, whereas the downward trend of efficiency persists over the entire copper range. A somewhat similar trend is observed in saturated $CaSO_4$ solution, although here the data are less complete and the efficiency level is some 10% higher, since the electrolyte is less aggressive and the current density is abnormally high for anodes operating in gypsum.

Surprisingly enough the data of Figure 11 show the downtrend of anode efficiency to be most pronounced in the 0.00-0.05% Cu range, an effect which gains further support from the data shown in Figure 12. In the latter graph, field test data are plotted for a composition of higher silicon content but containing a minimum of 0.15% Mn. The effect appears to exist for anodes tested at both soil resistivities.

Thus, while the data for copper are conflicting, there is a preponderance of evidence to indicate that this element can under some conditions be detrimental. There are likewise strong indications that improved copper tolerance can be obtained by maintaining a high manganese content (0.2%) but this

does not appear to completely offset the effects of copper. In some cases silicon or other impurities may be contributing in such a way as to confuse the picture. Further work is indicated if the effects of copper are to be clearly resolved.

Effect of Iron

There is no doubt that iron has a detrimental effect on the anode efficiency and that this effect depends, to a large extent, on the manganese content of the alloy as previously described and illustrated in Figures 4 and 5. Further evidence of the detrimental effect of iron is presented in Figure 13. These data show the rapid downtrend of the anode efficiency with increasing amounts of iron when the metal contains only 0.1% manganese. Also, when the metal contains 0.3% manganese the detrimental effect is much less pronounced but remains definitely noticeable in the lower iron ranges.

Thus, it is indicated from the data in Figures 4, 5 and 13 that iron should be kept below .003% with a manganese content of at least 0.15% for good anode efficiency when used at the current densities usually found in soil applications.

Effect of Silicon

Silicon is an impurity always found in magnesium alloy anodes and yet its effect on the anode efficiency has received little attention. The data presented in Figure 14 shows very little effect of the silicon up to about 0.10% but beyond that scatter becomes so great as to significantly reduce the average anode efficiency.

It can be concluded that a consistently higher anode efficiency can be obtained in metal containing less than 0.1% silicon.

Effect of Lead

Lead, a minor impurity in magnesium alloy anodes, shows very little effect on the anode efficiency in the amounts usually found in anodes. However, the data shown in Figure 15 indicate a pronounced detrimental effect when lead is present in amounts above 0.04%.

TABLE 4

Field Performance of Magnesium Alloy Anodes 50-100 ohm-cm. and 500-1000 ohm-cm. Resistivity Soils at Freeport, Texas, 12 Months' Test

Specification (6 Al-3 Zn Type Alloy)

Low Purity		Medium Purity		High Purity	
Cu.....10 Max.		Cu.....05 Max.		Cu.....02 Max.	
Fe.....003 Max.		Fe.....003 Max.		Fe.....003 Max.	
Ni.....003 Max.		Ni.....003 Max.		Ni.....002 Max.	
Mn.....10 Min.		Mn.....15 Min.		Mn.....15 Min.	
Si.....30 Max.		Si.....30 Max.		Si.....10 Max.	
Anode Efficiency		**Anode Efficiency**		**Anode Efficiency**	
50-100	**500-1000**	**50-100**	**500-1000**	**50-110**	**500-1000**
31.3	37.0	34.9	51.0	45.3	57.5
33.8	32.5	37.6	46.4	36.9	45.7
31.0	38.1	40.8	39.0	32.5	48.8
	49.2	44.9	45.1	41.8	51.2
	50.2	48.5	40.6	41.4	51.8
	41.0	32.8	40.0	42.6	37.2
	43.5				
	40.0				
Avg: 32.0%	41.4%	39.9%	43.7%	40.1%	48.7%

Effect of Tin

Tin, another minor impurity found in the alloy anodes, showed a slight effect on the anode efficiency. The curve in Figure 16 indicates a slight downtrend in the anode efficiency when tin is present in amounts above .005%. However, like lead, tin, in the amounts normally found in anodes, shows very little effect on the anode efficiency.

Effect of Beryllium

Although beryllium is not usually considered to be either an alloying element or an impurity in magnesium alloy anodes, its effect on the anode efficiency might be of interest because of the desirability of adding small amounts of this element to reduce oxidation during the casting process. The curves in Figure 17 obtained in saturated $CaSO_4$ at various anode current densities, using comparable alloy with and without beryllium, show that the addition of .0028% beryllium did not effect the anode efficiency.

Field Tests

To substantiate the results of the laboratory tests and to show the combined effects of the impurity elements, the results of a large field test carried out at Freeport, Texas, in both high and low salt soils were reviewed.

The various alloy compositions from this test were separated and grouped, regardless of the source of metal, according to the three composition specifications shown in Table 4. One corresponded to secondary alloy, the second to the old primary specification and third to a new primary specification. The anode efficiency obtained on each individual anode is listed below each specification.

The spread in anode efficiency within any one group may be cause for concern, but this amount of scatter is to be expected because of the wider composition limits allowed here as compared to the limits permitted in the laboratory tests and the fact that test conditions are most difficult to control in the field. Nevertheless the average anode efficiency of each group in both soils shows the higher purity metal producing the highest efficiency. This verifies the results obtained by the study of the effect of each of the impurity elements in the laboratory tests and demonstrates the fact that nickel, copper and silicon can have detrimental effects in combined amounts.

Summary

Laboratory investigation has shown that the efficiency of magnesium alloy anodes can be adversely affected by certain impurities at concentration levels well below those previously indicated by salt water corrosion data. The impurities of most concern are nickel, copper and silicon but detrimental effects are also noted with lead and tin at above normal concentrations. Based on these data a revised primary alloy anode specification (A of Table 1) has been introduced and its superior performance confirmed by field testing.

Alloying elements such as aluminum and zinc are without significant effect in the ranges ordinarily specified. Beryllium, at the concentrations employed

to prevent oxidation, is likewise without effect.

Iron levels as high as .02-.035% are well tolerated at manganese contents in excess of 0.2% but not without an appreciable sacrifice in efficiency. Low iron (<.003%) composition of intermediate Mn (>0.15%) content offers superior performance and a more practical casting composition.

The effects of copper are inconsistent but the bulk of the data indicate an adverse effect beginning at surprisingly low (<.05%) copper contents. There is some evidence to indicate that the effect of copper can be confused with or masked by the presence of other elements, notably silicon.

Manganese additions not only control iron content and iron tolerance but also appear to partially offset the effect of copper. A manganese content of 0.2% (min.) is indicated at high (0.1%-0.4%) copper levels for improved performance in saline environments.

Nickel can adversely affect anode efficiency at levels distinctly below previously recognized limits, an appreciable effect being observed down to as little as 0.0005% Ni. In primary grade alloy, a nickel maximum of .002% is indicated if efficiencies are to be held at or above 50% for the current densities obtained in underground service.

Silicon exhibits a detrimental effect at concentrations in excess of about 0.1%, the effect taking the form of scatter with an attendant reduction in average anode efficiency.

The minor impurities, lead and tin, have detrimental effects when present in amounts exceeding those normally found in anodes. Efficiencies fall off markedly for lead contents in excess of 0.04% whereas a slight downtrend of efficiency is indicated at tin levels above about .005%. Limits for these elements have not been included in the revised primary alloy specification largely because the lead and tin levels in this alloy fall well below the above limits.

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2. H. A. Robinson. *Trans. J. of Electrochemical Soc.*, **90**, 485 (1946).
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Coordination of Corrosion Control*

By HUGH W. HAMILTON*

Abstract

The author urges better coordination among users of cathodic protection for corrosion control. Coordination means interchange of information regarding proposed or operating control devices. Better engineering of proposed installations is needed in many cases to permit proper coordination. Preventive or corrective measures that are reasonable and practical should be followed where underground metallic structures of more than one company are involved. An example is given of a top management committee which oversees a utility's entire corrosion control program. The author believes that adequate coordination (which is the exchange of pertinent information based on careful engineering studies of each corrosion control project and participated in by management) will lead to effective and satisfactory corrosion control.

THE SUBJECT of coordination of corrosion control is one that primarily suggests the mutual effect of an underground structure under corrosion control, with reference to other underground structures. In a corrosion control scheme that is applied to a so-called "grounded structure" there are mutual effects on any adjoining structure. The degree of effect on the other structure, or structures, is in direct relation to several electrical phenomena. The geometry of piping layout and the relation of the anode, ground bed or rails that is forcing currents into the earth is of first consideration. The electrical conductance of the soil and the protective coating applied to the structures, if any, will in large degree determine the proportion of interference effect as well as the physical extent of mutual effect. Last but not least is the amount of electrical current involved.

This interference effect will be noted on structures other than the one to which a corrosion control method is applied. The effect is that a degree of electrical current may find its way to the foreign structure, flow on this foreign structure and eventually leave to complete the circuit. If this unintentional current flow has no other path but the earth to follow, from the foreign structure to the home structure, then aggravated corrosion results. No corrosion will occur if proper steps are taken.

Generally speaking if the total amount of electrical current under consideration is less than one ampere, no aggravated interference effect is to be anticipated. Many corrosion control currents may reach or exceed 100 amperes. This then points out the wide variety of current level. The field of influence of these currents that are caused to flow through the earth, and collect on a structure, can be of large magnitude. It is not unusual to notice this effect 10 miles distant from the source. Keeping in mind that one ampere of discharge for one year will dissipate approximately 20 pounds of iron or 70 pounds of lead makes it apparent why this selected subject is important.

The only manner in which this possible hazard may be held to an agreeable level is by the interchange of information regarding proposed or operating corrosion control devices. The usage of the word "coordination" is to indicate this exchange of information between neighboring utilities operating underground structures. A condition that requires coordination can be the result of stray traction current drainage and/or cathodic protection.

There has been a tremendous increase in the employment of corrosion control means. Transmission type mains with good electrical continuity, better application of improved protective coatings, and the test of time that such work is successful all have lent impetus. Greatly expanded facilities, increased operating pressures, cost of labor and materials all have demanded that more recognition be given to cathodic protection as a means of saving money and assuring supply. However, this inrush of activity has incipient hazards which management must consider.

A.G.A. report DMC-53-3 presents some very interesting data of particular interest as regards this subject. It should be noted that the cost of corrosion control is reported as a median value of $85,000 annually and that the total median cost of leaks due to corrosion and the cost of corrosion control is approximately $200,000 annually. These reported values are from 29 companies who returned questionnaires completed in sufficient detail to allow statistical analysis. It is also apparent from this report that the use of cathodic protection is increasing tremendously. We then are discussing a situation which is not only faced with greater employment but also one that involves the expenditure of many thousands of dollars.

It is our opinion that, if greater consideration is not given to the proper coordination of corrosion control as to its effects on the properties of others, some action might be sought in the courts. This can and should be avoided. Consideration for the property of others is all that is required.

It is not our purpose here to discuss the engineering facets of cathodic protection interference problems. The topic has been very well covered in other papers. A. V. Smith presented a paper at the 20th Annual Distribution Conference of A.G.A. entitled "Cathodic Protection Interference." This reference is basic and practical in its engineering approach and is highly recommended to those interested in pursuing the engineering solution. At the 20th Annual American Petroleum Institute Meeting, L. F. Scherer discussed

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the subject problem and I would like to quote a paragraph from this paper.

> "The rapid increase in recognition, and the general use of this form of protection, clearly indicate that the mutual problems arising soon will reach the point where they can no longer be handled amicably through individual agreement. Because of the tremendous liabilities which may be created through lack of understanding, good practice, or standardization, the directed control of this work soon may become a serious concern of the entire industry."

This statement is more applicable to the gas industry than any other industry employing underground pipe, because the gas industry has more buried plant than any other industry. The National Association of Corrosion Engineers published a report in 1951 by the "Correlating Committee on Cathodic Protection." The American Gas Association was a sponsor organization in this work and was represented by Messrs. Corfield and McElhatton. There were 11 sponsor organizations involved in the preparation of this valuable report. The report is very comprehensive, giving detailed suggestions for coordination of activity, addresses of established electrolysis committees, where to obtain maps, selected bibliography, etc.

With these references to papers dealing with the subject of "Coordination of Corrosion Control," the question might well be asked: Why is it being discussed here today? The reason is that there are many cases to our certain knowledge where the use of corrosion control has been employed with an apparent disregard for the rights and property of others. These matters have been discussed in detail with other corrosion engineers and it was the opinion of the Corrosion Committee that there was sufficient importance to the subject to warrant spending this time. These discussed cases have involved situations where (1) stray current traction bonds have been installed without notification to others occupying the same area; (2) the installation of ground beds to be used in conjunction with a rectifier in which the ground bed has been located adjacent to another underground structure without notifying others of the installation; (3) the alteration of electrical configuration of a structure without notifying others of the change; (4) abandonment of a protective scheme without notification to others involved; (5) the wholesale installation of cathodic protection schemes where engineering design has not been adequately considered so that the desired result has been nullified after interference currents were considered.

These situations not only affect disposition but cause an unwarranted expense. A well planned installation is definitely the least expensive and most successful.

We feel that one or two, or a combination of causes, are contributory: (1) that the engineers performing the field work have not been thoroughly trained and advised of their responsibilities in regard to possible mutual effects; and (2) that management is pressing for completion of the work and not allowing the field engineers sufficient time to adequately consider the installations. This press of time might result due to the apparent "out of balance" in engineering costs, versus, total installation costs. The control of corrosion is one that involves what might be termed field research. Obviously this is expensive engineering. However the actual cost of a protective installation is usually of proportionately minor financial outlay. This may be one of the causes for a possible hurry-up management approach. The proper training and advice on attendant responsibility is obviously of paramount importance. Unless improved coordination results are achieved, some difficult and arbitrary legislation might ensue. In pursuing this caution, some legal literature has been researched. In summary of these cases, it is apparent that potential defendants cannot with impunity permit stray electric currents to cause damage to pipes of potential plaintiffs. Preventive or corrective measures that are reasonable and practical must be followed. Unless these measures are followed the potential defendants are liable to those persons whose property they have damaged. The unescapable factor present in all these cases which seems to be of paramount importance is that the courts recognize the damage caused by stray currents and will charge all the litigants with knowledge of potential damage. All liability in tort action is predicated first and foremost on a defendant's negligence. If a defendant is not negligent, he is not liable and conversely if he is negligent he is liable. To discuss something that is more dramatic than corrosion, we could take the case of a defendant who handles explosives carelessly. If damage occurs he is liable, but if he handles the explosives carefully and in the manner recommended and approved by other handlers of explosives and damage results, he is not liable. It then behooves all of us to take reasonable precautions in corrosion control so as not to be held liable. The cases studied conclusively establish that industry must take cognizance of the electrolysis problem, particularly as regards potential liability of corrosive damage to another's structure. If preventive measures are taken and they are applied in a reasonable and practicable manner there can be no problem. If the proper measures are not taken there can be a strong argument that all that was reasonable and practicable was not followed. Several states in the Northeast region of the country have set up rules under their public service commissions. In these rules there are definite stipulations as to corrosion control measures to be followed when pipelines are constructed that are to carry gas in excess of certain pressures. At the moment these rules are not too stringent. However the door has been opened on the subject and if further attention is called due to an unfortunate situation, more difficult rules are to be anticipated. As stated previously this can and should be avoided.

A large Eastern combination utility has taken positive steps in this direction. A top management committee was established to study and oversee the entire corrosion control program. Under this top management committee, there is established a working committee, consisting primarily of the engineers responsible for corrosion study. This then serves a dual purpose in that the entire corrosion picture is

viewed from a management viewpoint and the field activities are carefully effected.

In conclusion to accomplish adequate coordination of corrosion control the following steps are recommended:

(1) Instruct properly trained engineers as to possible attendant hazards regarding the property of others.

(2) Allow sufficient time for these engineers to thoroughly pursue the problem.

(3) Explore new areas that are to be embraced by new construction to determine location of other underground structures and what, if any, corrosion control means are employed.

(4) Notify your neighbors of:

(a) Planned cathodic protection schemes before installation so that interference tests may be conducted.

(b) Installation of drainage bonds whether to another pipeline or traction rails.

(c) The abandonment or alteration of any protective scheme by which they might be affected.

(d) Changes in electrical configuration that would alter the protective design.

If these steps are followed, it is our opinion that adequate coordination of corrosion control will result.

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Minimizing Damage to Adjacent Structures In Urban Cathodic Protection Installations*

By D. T. ROSSELLE

IN DISCUSSING cooperative corrosion control in urban areas it might be well to cover briefly some problems encountered in the South. The intricate mass of interconnected subsurface metallic structures in the normal urban area offers a fertile field for corrosion, particularly where earth resistivity is low. This condition is further aggravated in cases where dissimilar soils are encountered and the structures have a nonuniform environment.

In the majority of the larger cities stray current from street railway systems was utilized to override galvanic currents and in effect, provide cathodic protection to most underground plants. In recent years the rapid conversion to unigrounded trolley buses and motor coaches in these areas has deprived the underground structures of this means of corrosion mitigation. This is especially true in the South where the growth rate of the past few years has exceeded the national average. In these cases it is only reasonable to expect some galvanic currents and resulting corrosion.

Corrosion mitigative measures can be applied either to an individual plant or to the entire mass of subsurface structures as a unit. The best and most logical approach to the solution is a cooperative one. Unfortunately, it is not always possible to secure active interest from all parties concerned. This is understandable because structures differ so widely and the effects of corrosion become apparent on some plants long before they do on others.

Loss of Lead Is Quicker

As an example, the metal weight loss per ampere per year of lead is approximately three times as great as that of iron or steel. Further, the weight per lineal foot of most water and gas mains generally is greater than that of lead cable sheath. From this it can readily be seen that the operators of underground lead cables can be expected to become aware of bad corrosion conditions long before those operating ferrous structures. This does not mean that the ferrous stuctures are not being corroded at the same time or that corrective measures are not warranted.

Cathodic protection currents required to protect bare metallic structures in urban areas generally are greater than can be obtained from galvanic anodes of magnesium, zinc or aluminum alloy. Therefore, for the purpose of this discussion the use of rectifiers or some similar source of direct current is assumed.

★ A paper presented under the title "Cooperative Test Methods for Corrosion Mitigation Problems in Urban Areas," at the Tenth Annual Conference, National Association of Corrosion Engineers, Kansas City, Mo., March 15-19, 1954.

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Abstract

Examples are given of methods whereby structures adjacent to underground plant put under cathodic protection can be protected from damage as a result of picking up current. Bonding, with proper consideration to the reason for the bond, is urged. Bonds should be calibrated and test leads provided for future investigation of changes that may take place in potentials. An example is given of an instance in which cross-bonding did not provide sufficient protection for a telephone cable adjacent to a pipe line put under protection.

Damage to adjacent structures may be minimized by distributing anodes parallel to the structure to be protected and by using as many small rectifiers as is economically feasible.

The author believes cooperative committees, such as are in operation in numerous urban areas of the country are the real answer to cathodic protection interference problems. Advantages of cooperative protection of all underground structures in an area are emphasized.

When individual treatment is given to one plant it is extremely difficult to apply adequate cathodic protection without some of the protecting current being collected by another structure. This current in turn must return to the plant under protection and in doing so often creates a condition which most often is eliminated by bonding between these structures. Bonds also are required in numerous cases when all plants are being protected as a unit.

Bonding Requires Thought

Bonds of this type require considerable thought prior to placing. The first consideration should be the objective of the bond. If all structures are being treated as a unit the bond should be of sufficient size and located so as to afford the optimum distribution of the protective current with the objective of making all stuctures negative to their environment. If the bond is placed to eliminate the hazard to one structure caused by protection placed on an individual plant, its purpose is solely to eliminate

that hazard and is not intended to afford complete protection to both structures. The objective of this bond then, is to eliminate any potential shift to positive, between the other structure and its environment. This will necessarily afford limited protection to the other plant.

Bonds of this type often are located at points where crossings occur. It might be well to point out that in crossings the important point is the potential of each structure to its own environment rather than the potential difference between structures.

To illustrate this point, consider two structures which at a crossing are of equal potential and each in turn are —0.2 volts to their immediate environment. Then plant "A" is afforded cathodic protection that shifts its potential with respect to plant "B" to —0.1 v. Even though plant "B" then would be positive with respect to plant "A" it could not possibly be discharging current to ground at that point and consequently could not be adversely affected. This shows that even though one plant is positive to another at a crossing, it does not necessarily follow that there is any current exchange between them. If this point is kept in mind during joint testing on protective current influence many needless bonds will be eliminated.

Another consideration in cross bonding plants that should be kept in mind is the possibility that due to additions to either plant the resistance of the bond might have to be changed. It is advisable to calibrate all bonds because they often are inaccessible for inspection and if properly calibrated can be periodically checked for current flow. This check will indicate not only the condition of the bond but the relative potential between structures which might change from time to time due to additions or other causes.

Calibration Is Easy

Calibration can be accomplished easily by attaching insulated wires to two reasonably separated locations on the bond wire and extending these wires to an accessible location. At the time the bond is placed, simultaneous readings are made with a millivolt meter across the calibration wires and an ammeter or shunt in series with the bond wire. A record is then made of the amperes per millivolt or millivolts per ampere, whichever is appropriate. Future current measurements then can be made easily by means of millivoltmeter readings across the calibration wires without disturbing either bond connection.

In some cases bonding at crossings will not provide adequate protection to other structures when current is being applied to an individual plant. As a specific case of this type, early in 1953 the Memphis Light, Water and Gas Division engergized an installation designed to protect an "air lift" pipeline. This line, approximately 1.7 miles long consisted of one or more 10-inch bare steel pipes. It carries compressed air at 200 lb. per square inch to force water from deep wells along the route. In this installation the ground bed was located approximately 2000 feet south of the center of the exposed area of the pipe

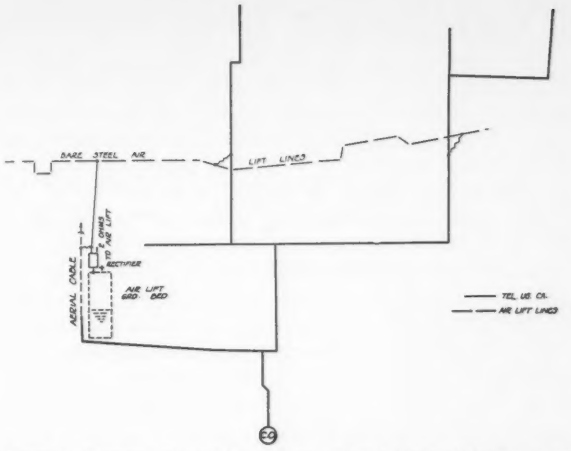

Figure 1—Diagram of air lift pipe line and telephone cable system at Memphis, Tenn., showing location of bonds and other measures taken to protect cables.

and the rectifier located at the ground bed. About 100 amperes was used on the initial tests.

Prior to energizing the installation all other operators of underground structures in the vicinity were notified. In order to make its plant least susceptable to the influence of the current, the telephone company isolated all underground cable sheath in the influence area from grounded structures. Figure 1 shows the location of the two plants involved.

How Cables Were Protected

Initial tests indicated, as was expected, that the telephone cables were picking up current in the vicinity of the ground bed where the cable-to-earth potential was reduced to a rather high negative value. At the same time current was being lost from the cables at each crossing. Bonds were placed at each crossing point and a total of 9.0 amperes drained from the cables. After these bonds were established a test was made on the cables just outside of the influence area of the ground bed and it was found that about 5.0 amperes of current was flowing on the sheath away from the ground bed. A resistance bond was then placed from the cables near the ground to the negative side of the rectifier and adjusted to drain 5.0 amperes. This resulted in making the cable to earth potential at that point still more negative but it also cancelled out all of the current on the sheath that was formerly flowing away from the point. Further it reduced the current in the original bonds from 9.0 to 7.2 amperes. It can be assumed that this approximate difference in bond current or 1.8 amperes was picked up at the ground bed location prior to the rectifier installation and carried to the crossings by the cable sheath.

If this is true, what became of the balance of the 5.0 amperes found flowing away from the ground bed area? It is assumed this current was being discharged in a manner that might damage the sheath and that the resistance bond at the rectifier was required to protect the telephone cables.

This method of stopping protection current at the source appears to have been the simplest solution

to this particular problem and might be applicable to other similar installations.

As stated previously, the most logical approach to subsurface structure protection in urban areas is to treat all plants as a unit and apply sufficient current and cross bonding to make all surfaces negative to their environment. A typical case of this type of installation was briefly described in an article by the writer which was published in the June, 1953, issue of CORROSION.[1] It outlined the plan that was successfully put into operation in downtown Miami, Florida.

In treating plants on an individual basis, the main objective is to make all of that particular plant negative without adversely affecting any other plant. This is usually quite difficult to do without some cross bonding but, in some instances, bonding proves to be the most economical solution.

Isolation Is Mammoth Task

First step in individual plant treatment is isolation or rather insulation of the plant to be protected from all other grounded structures. This in itself is a mammoth task in most urban areas and in some types of plant it is practically impossible to maintain. In considering this method it should be kept in mind that structures of this type do not generally retain their status quo. Additions, rearrangements and other changes continually alter the picture and unless this isolation is ridgidly maintained the effectiveness of the protective current is lost. Another factor that makes isolation of any particular plant difficult to maintain is that generally the isolation is contrary to existing electrical protection practices and the people who work on the plant through habit tend to upset the isolation unless they are thoroughly familiar with the objective.

In applying cathodic protection to an individual plant, it is always advisable to use as many small current installations as is economically possible rather than a few larger installations. This will allow the potential objective to be reached with less total current and also tend to reduce extreme potential differences between structures. This means that more uniform structure-to-earth potentials can be obtained over a considerably greater area with five 10-ampere installations as opposed to one 50-ampere installation. The current density will be less in the vicinity of the anodes and less likely to disturb other plants.

Dispersing Anodes Helps

Additional current dispersion can be obtained by distributing the anodes used over a considerable area parallel to the structure to be protected. Except in the case where abandoned street car rails are employed, this solution does not readily lend itself to urban application. However, an application of this type is now being planned by the Long Lines Department of the American Telephone & Telegraph Co. in Greensboro, N. C. In this case it is planned to use steel rods as anodes, one to be placed at the base of each pole along the route of the cables for a distance of about 2½ miles. The current in each rod is to be limited to about .050 amperes. Preliminary tests indicate that adequate protection can be obtained in this manner without affecting other subsurface structures.

Another method of distributing the current has been successfully employed in Miami and Jacksonville, Fla., by using cable conductors in the telephone cables to collect current from the sheath in several locations and carry it to the negative terminal of a remotely located rectifier.

In conclusion it may be said that when corrosion occurs on subsurface metallic structures in urban areas, it is only the logical result of normal operation and not an unusual or abnormal condition. So many people think that when corrosion occurs it is the result of some unusual condition, whereas unless something is done to prevent it, it can only be expected to occur.

In several cities in the South cooperative committees have been established. These committees have been comprised of all parties interested in subsurface corrosion and in each and every case have proved beneficial to everyone and appear to be the most logical approach to the solution of corrosion problems in urban areas.

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Laboratory Studies on the Pitting of Aluminum In Aggressive Waters*

By T. E. WRIGHT and HUGH P. GODARD

Introduction

IN THE STUDY of the pitting corrosion characteristics of aluminum in these laboratories, it has been found that the municipal supply water provides a medium that will induce pitting on commercial aluminum alloys.[1] Accordingly, Kingston tap water was adopted as a convenient "standard" pitting medium for the determination of pitting susceptibility and pitting rate curves of various aluminum alloys. It was reasoned that the relative behavior of the alloys in Kingston tap water would be similar in other fresh waters of a pitting type. The assumption was made that the water was corrosive by virtue of its natural chemical composition. However, the possibility also existed that its pitting tendency was due to water treatment or to heavy metal contamination in the city water system. If this were so, it would be a much less valuable corrosion test medium in pitting studies and for this reason the present tests were carried out to determine whether Kingston tap water was more aggressive than Lake Ontario from which the former is drawn.

In previous unpublished work, it had been found that aluminum sheet and extrusion specimens protruding from concrete blocks immersed to a shallow depth near the shore of Lake Ontario for a period of one year did not pit. Also, it was known that aluminum row boats and canoes do not suffer pitting. As these experiences appeared to differ from our laboratory test results with Kingston tap water, there was added stimulus to make a controlled laboratory test.

In the present work it was found that water drawn directly from Lake Ontario has the same pitting tendencies to aluminum as Kingston tap water, while on the other hand, specimens immersed directly in the Lake did not initiate pitting. From this, the conclusion was drawn that water velocity may prevent the initiation of pitting and a controlled laboratory experiment was then made to provide information on this point. This showed that velocity affected both the probability and pitting rates.

A third section of this paper deals with a study of specimen preparation for the determination of pitting rate curves in tap water. In the past, the technique here has been to etch in hot phosphoric acid, rinse briefly in water and immerse directly in the aggressive tap water. This treatment removes the mill formed oxide film on the metal and develops a thin new film which permits the initiation of pitting. It has been found that pitting initiates on the first day of immersion which is desirable so that the zero point on the pitting rate curve is known. Unetched panels of aluminum pit also, but there is a time to initiation which varies with the specimen and alloy and this confuses the preparation of pitting rate curves. Several variations of specimen preparation were investigated, including boiling in water. The latter is of

★ A paper presented at a Corrosion Symposium held in Ottawa August 31-September 2, 1953 by the Associate Committee on Corrosion Research and Prevention of the National Research Council of Canada. Submitted for publication February 8, 1954.

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HUGH P. GODARD—Since 1945 his principal interest has been research on the corrosion behavior of aluminum. He holds a PhD in Industrial and Cellulose Chemistry from McGill University and a master's degree in chemical engineering from the University of British Columbia. He has worked in the fields of wood pulp, copper and gold mining and explosives before joining Aluminium Laboratories, Ltd. in 1945. He is a member of the NACE board of directors, a past chairman of the Inter Society Corrosion Committee, 1953 chairman of the Gordon Research Conference on Corrosion and a member of the Canadian Associate Committee on Corrosion Research and Prevention.

Abstract

Tests indicate the pitting tendency of Kingston tapwater is a result of its intrinsic composition and not a consequence of contamination from the city water system. It is shown that movement of water reduces both pitting probability and rate and that beyond a certain velocity, no pitting occurs.

Several variations of specimen preparations were investigated including boiling in water.

TABLE 1—Composition of Metal Tested

Alloy	Thickness	PERCENT Cu	Fe	Mg	Mn	Si	Ti	Cr
Lake vs. Tap Water Experiments								
2S—¾H	0.064"	0.03	0.66	....	....	0.13	....	....
3S—½H	0.064"	0.02	0.55	....	1.08	0.28	0.02	....
57S—½H	0.064"	0.05	0.20	2.26	....	0.14	0.02	0.23
Velocity Experiments								
2S—H	0.064"	0.03	0.44	....	....	0.32	<0.01	....
Etching Experiments								
2S—0	0.025"	0.02	0.44	....	....	0.14	0.01	....

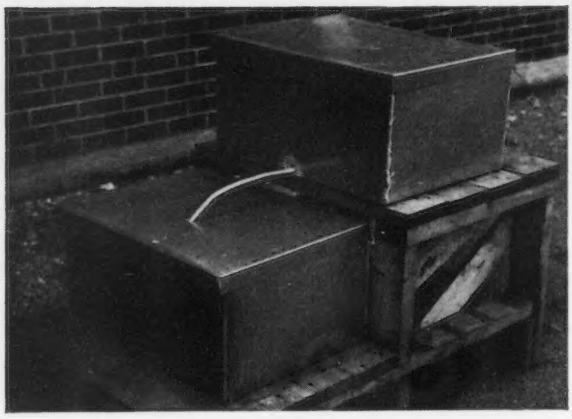

Figure 1—Apparatus for lake water vs. tap water tests.

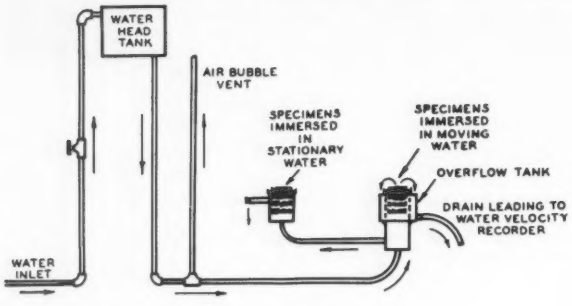

Figure 2—Water velocity apparatus.

some interest in that it has been suggested as a protective step for treating aluminum cooking utensils.

Description of Material

Specimens were cut from 2S, 3S and 57S sheet produced at the Kingston Works of the Aluminum Company of Canada. The composition of the alloys used is presented in Table 1.

Experimental Procedure and Results

1. *Comparison of Kingston Tap Water and Lake Ontario Water*

For the tapwater-lake water corrosivity experiment two small tanks 24 x 18 x 12 inches were made from aluminum sheet. One was placed outside the laboratory in the shade of shrubbery, while the other was placed at the lakeside some three miles away in the shade of trees. At each location a second similar "reservoir" tank was placed above the testing tank with a constricted feed line to the latter. Once daily the upper tank was filled with fresh water from either tap or lake. This then drained slowly (over a few hours) into the lower tank giving a change of water without appreciable velocity. The arrangement is shown in Figure 1.

Three alloys, 2S, 3S and 57S, were tested in the form of 2 x 5 x 0.064-inch sheet specimens. Groups or "strings" of ten coupons were threaded onto glass rods and separated by half inch spacers of rubber tubing. Six strings of each alloy were prepared. Of these, two were degreased in trichlorethylene while the remaining four were etched for two minutes in 85 percent phosphoric acid at 70 degrees C followed by rinsing for 30 minutes in running water. The strings were transported to the testing tanks in jars of tapwater and transferred while wet. Strings of etched coupons were removed after one, two, four and six weeks' immersion while the unetched strings were removed after the final period.

At the same time, two strings of each alloy, one etched and one not etched, were immersed in Lake Ontario about thirty yards off shore at a depth of about three feet and some five miles from city sewer mains. These were removed after 26 days' exposure.

At the conclusion of the test, the number of pits on each coupon and the maximum pit depth was determined using a calibrated microscope for pit measurements.

No pitting occurred on either etched or unetched coupons immersed directly in the Lake after 26 days. A summary of the results obtained in Lake and tap water under quiet conditions is shown in Table 2.

The number of pits formed on 2S and 3S in the Lake water was less than in tap water but the reverse was true of 57S. The maximum pit depths were slightly more in tap water although the difference was not large. The results make it clear that while Kingston tap water was slightly more aggressive than the Lake water, there was no major difference in the pitting characteristics of the two waters toward aluminum. This was further confirmed by carrying out pitting probability tests on the three alloys using the method already described.[1] After one week, pitting probability results shown in Table 3 were obtained.

From this it was concluded that the aggressive pitting nature of Kingston tap water to aluminum was by virtue of its intrinsic composition and not because of impurities picked up in the city water

TABLE 2
Number and Depth of Pits on Aluminum in Lake and Tap Water

Alloy	Condition	Time	Number of Pits Per Coupon		Avg. Depth of Pits (μ)		Max. Depths of Pits (μ)	
			Lake	Tap	Lake	Tap	Lake	Tap
2S	Etched....	1 wk.	1	1	135	60	310	220
		2 wks.	1	2	155	265	310	360
		4 wks.	3	5	215	550	500	700
		6 wks.	1	11	90	460	400	670
	Not etched	6 wks.	1	1	10	10	60	30
3S	Etched....	1 wk.	1	7	50	245	170	330
		2 wks.	1	19	40	265	180	310
		4 wks.	1	37	95	410	220	540
		6 wks.	2	44	80	495	200	690
	Not etched	6 wks.	1	1	0	10	10	50
57S	Etched....	1 wk.	>100	13	250	205	400	310
		2 wks.	>100	70	230	320	380	530
		4 wks.	>100	50	255	425	440	520
		6 wks.	>100	37	175	365	270	520
	Not etched	6 wks.	0	42	0	105	0	180

TABLE 3—Pitting Probability Results in Lake and Tap Water

Number of Squares	2S		3S		57S	
	Tap	Lake	Tap	Lake	Tap	Lake
With no pits	44	29	40	36	29	29
With one pit	36	41	40	40	43	48
With more than one pit	28	38	28	32	36	31

system and accordingly that it was a suitable testing medium for pitting studies with aluminum in aggressive fresh waters.

It was interesting to find that the panels immersed in the lake proper near the shore did not pit. This is attributed to the movement of the water at the bottom of the lake which was fairly rough during the test period.

TABLE 4—Number and Depth of Pits vs. Velocity in Kingston Tap Water

Velocity fpm	CONTROL PANELS IN STILL WATER						TEST PANELS IN MOVING WATER					
	No. of Pits Per Panel			Max. Pit Depth Per Panel (μ)			No. of Pits Per Panel			Max. Pit Depth Per Panel (μ)		
	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
1	95	126	51	206	270	140	244	380	124	148	220	100
2	360	456	200	156	180	110	145	227	77	107	150	80
3	126	60	203	176	250	100	26	37	8	79	100	50
4	174	231	103	227	360	170	58	92	41	90	140	60
5	119	152	81	236	380	150	26	31	17	50	80	40
6	142	260	91	156	200	120	15	30	5	35	60	20
7	347	515	191	133	160	80	50	86	30	29	60	10
8	59	110	31	155	300	100	0	0	0	0	0	0
10	85	125	62	188	360	130	0	0	0	0	0	0

2. *Influence of Water Velocity on the Initiation of Pitting*

To study the influence of water velocity the apparatus shown in Figure 2 was constructed in the laboratory. This consisted of a 10-inch vertical length of smooth-walled aluminum tubing with an inside diameter of 5 inches. Water from a constant head tank was introduced at the bottom and caused to flow past a number of perforated plates near the bottom of the tube so as to give an even rate of flow upward through the pipe. The water overflowed the top of the pipe to drain. A similar length of pipe was arranged nearby so that the same water filled it and overflowed at a drop wise rate so that conditions in this tube would be essentially quiet.

A string of ten coupons of 2S sheet 2 x 2 x 0.064-inch was placed in each container, the surface being prepared by etching in phosphoric acid as already described. The duration of each test was seven days, at the end of which the number of pits and the maximum pit depth on each coupon was determined. Runs were made at different water velocities from one to 10 feet per minute. The rate was determined by measuring the time to collect a given volume of discharge. The water temperature was adjusted to approximately 20 degrees C. The pitting results are shown in Table 4.

The number of pits and maximum pit depths both decreased with increasing water velocity until at 8 feet per minute no pitting took place. Owing to the scatter in results, which are based on only a small number of specimens, little is gained by attempting to plot them. A practical note can be injected at this point to the effect that aluminum sheet logging flumes have proved extremely satisfactory in many parts of Canada where water velocities are on the order of 7 feet per second. There has been a complete absence of pitting.

3. *Influence of Various Surface Treatments*

For this work, thirty coupons each of 2 x 5 x 0.064-inch sheet were arranged in strings of ten. All tests were performed in a 300-gallon pitting tank previousy described,[1] filled with Kingston tap water changed about once daily. The following surface treatments were investigated:

1. Vapor degreasing in trichlorethylene.
2. Standard hot phosphoric etch and rinse and direct transfer to the pitting tank.
3. Standard hot phosphoric etch and rinse but allowed to stand in air for two hours prior to placement in the pitting tank.
4. Standard acid etch and rinse but boiled two hours in distilled water before placement in the pitting tank.
5. Vapor degreased in trichlorethylene and then boiled in 10 percent potassium dichromate solution for two hours. In this case there was no etch. The specimens were rinsed for thirty minutes in cold running water prior to immersion in the pitting tank.

TABLE 5

Pitting Results in Kingston Tap Water of 2S Aluminum Pretreated by Various Methods

Pretreatment	Average No. of Pits Per Panel	Average Depth (μ) (of Deepest On Each of 30 Panels)	Deepest Pit On All 30 Panels (μ)
1. Vapor degreased only	1	10	110
2 Phosphoric etch—water rinse	15	225	295
3 Phosphoric etch—water rinse—air dry 2 hours	20	210	285
4 Phosphoric etch—water rinse—boiling water 2 hours	65	255	415
5 Vapor degrease—boiling water—2 hours	1	20	90
6 Vapor degrease—boiling 10% $K_2Cr_2O_7$ for 2 hours—water rinse	1	20	160

After one week's immersion in the tank, the specimens were removed and the number of pits on each panel and maximum pit depth determined.

It was observed that after a few hours of immersion all the panels etched in phosphoric acid had started to pit. Results are shown in Table 5.

It is evident that in all cases where phosphoric acid was used as part of the surface treatment, the number and depth of pits is much greater, regardless of whether the panels were boiled in distilled water or allowed to dry in air. It had been anticipated that both of these treatments would allow the oxide film to grow to an extent that the pitting resistance of the panels would increase but this was not the case.

Conclusion

It is considered that the use of Kingston tap water as a pitting test medium has been justified and the phosphoric acid specimen preparation treatment was found to be less critical than expected. It was clearly shown that the initiation of pitting of aluminum in an aggressive water is greatly influenced by movement of the water over the surface and beyond a certain moderate minimum velocity no pitting will develop. It also was found that water movement will reduce the rate of pitting.

The influence of water composition on its pitting

tendency toward aluminum is a subject that has not yet received much attention. A general statement is that of Sawyer and Brown.[2] Work in progress in England has been reported.[3] This laboratory's experience is that fairly hard, mildly alkaline water such as in the Great Lakes System tends to pit aluminum, while soft, mildly alkaline or mildly acid waters do not. Specifically, it is known that the tap water in Arvida, Quebec and Ottawa, Ont., are not aggressive to aluminum. These have the following characteristics:

	Ottawa	Arvida
pH	8.6	8.1
total solids (p.p.m)	100	59
total hardness (p.p.m)	46	25

Aluminum piping has been used successfully to carry water in a number of locations in the Aluminum Company plant at Arvida for periods up to eight years. Examination of pipe specimens indicates little or no pitting and long probable life. Aluminum water piping was placed in some 200 dwellings in a post-war CMHC housing development in Ottawa in 1947. Since then it has given no trouble and specimens examined recently were free of pitting after six years' service. In contrast, galvanized steel piping and hot water tanks in other houses at the same location have required frequent maintenance.

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Corrosion of Nickel Cast Irons in Soils*

By IRVING A. DENISON and MELVIN ROMANOFF*

Abstract

The results of measurements of the corrosion and of the strength of nickel cast irons after exposure to different soil conditions for a maximum of 14 years are reported. The magnitude and progress of corrosion, as determined by weight-loss and pit-depth measurements, are correlated with the composition of the materials and the nature of the environmental conditions to which the specimens were exposed. The residual strength of the corroded cast iron that had been removed from the more corrosive soils was evaluated by subjecting the pipe specimens to hydraulic pressures up to 500 lb/in².

1. Introduction

CORROSION of cast iron in soils is characterized by the development of an adherent layer of corrosion products that increases in thickness as corrosion progresses. The thickening of this layer is due in part to electrochemical action between the ferritic and graphitic constituents of cast iron and partly to differences in potential that arise from contact of the cast metal with the soil, as, for example, by differential aeration. To the extent that corrosion of cast iron is caused by differences in potential within the metal itself, improved corrosion resistance would be expected to result from improvement in the quality of the casting. Wesley, Copson, and LaQue[1] have shown that the addition of small amounts of nickel and nickel plus chromium alters the structure of cast iron in such manner that galvanic action between the different constituents is reduced considerably. Larger additions of these alloying elements in amounts sufficient to produce an austenitic structure were shown to be considerably more effective in reducing corrosion under the experimental conditions because of the ennobling effect of nickel and chromium on the potential of iron.

In order to evaluate the effect of additions of nickel and of nickel plus chromium on the corrosion of cast iron in soils, samples of alloy cast irons were included in an extensive series of exposure tests of materials for underground construction. In 1932, samples of a high-alloy austenitic cast-iron pipe were buried at 15 test sites, and in 1941 samples of several low-alloy cast irons were buried at 13 of the same test sites, and at one other site. In a previous report,[2] corrosion data were reported for five periods of exposure for the samples of high-alloy cast iron and for a single period for the samples of low-alloy cast irons. With the completion of the exposure tests in 1952, data for the latter materials became available for four periods of exposure, with a maximum exposure of 11 years.

After removal of the samples from the test sites, the procedure followed during the early periods of the exposure program was to clean the samples of all corrosion products preparatory to measuring the weight losses and the depths of the deepest pits. This procedure was later modified by subjecting those samples in the form of pipe to hydraulic pressure before removal of the corrosion products. This modification was introduced in order to evaluate the strength of the corrosion products remaining in the pits of the samples that had been perforated by corrosion. The methods used for cleaning the corroded samples and for measuring the depth of pitting have been previously described.[3]

2. Properties of the Soils at the Test Sites

The location of the test sites, the identification of the soil types, and the properties of the soils that are associated with corrosion are given in Table 1. The retentiveness of the soils for water is indicated by the values for moisture equivalent, which is the quantity of water retained by a previously saturated soil against a centrifugal force of 1000 times gravity. Because the real specific gravities of rock-forming minerals lie within a narrow range, values for apparent specific gravity are an index of the relative compactness or porosity of inorganic soils.

3. Description of the Materials

The forms, dimensions, and compositions of the specimens are given in Table 2. The ends of the pipes were closed with cast-iron screw caps of the same composition as the specimens in order to exclude moisture from the interior. As an extra precaution against internal corrosion, the interior surface of the specimens was coated with heavy grease.

4. Weight Losses and Maximum Pitting

The data of Table 3 indicate that the high-alloy cast iron E was considerably more resistant to corrosion, as measured by both weight loss and the maximum pitting, than either the plain cast iron A or the low-alloy cast irons B, C, D, NC and N. It is noteworthy that, except in cinders, the deepest pit measured on the specimens of material E in more than 14 years of exposure was only 74 mils.

The effect of composition on the corrosion of the low-alloy cast irons can be observed to somewhat better advantage by calculating the weight losses of these specimens on a relative basis. This would have the effect of eliminating the differences in corrosivity of the soils due to differential aeration and emphasizing the effect of graphitic corrosion. In Table 4 the weight losses of materials B, C and D are shown for each soil and for each period of exposure relative to

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* National Bureau of Standards, Washington, D. C.

the plain cast iron A. Except for the well-drained soils of high resistivity (soils 53, 55 and 62), and soil 66, in which accelerated corrosion of the alloy cast irons occurred, the relative weight losses of the specimens during the initial period of exposure is seen to have decreased with increasing content of nickel. For example, during the first period of 5 years' duration the weight losses of material D in soils 58 and 63 were only 20 and 16 percent, respectively, of the weight losses of plain cast iron in the same soils for the same period. However, this initial advantage from the addition of nickel was usually not maintained, with the result that the weight losses of the alloy cast irons exposed for the maximum period usually did not differ greatly from the losses of plain cast iron. Hence, it would appear that the rates of corrosion of the alloys containing the higher amounts of nickel decrease less with time than do the rates for the alloys containing the lower amounts of nickel and plain cast iron.

5. Strength of Corroded Cast-Iron Pipe

Corrosion of cast iron in soils is characterized by the conversion of the metal into a layer consisting chiefly of oxides of iron and graphite. Although the original shape and appearance of the metal are retained, visual observation gives no indication of the extent of corrosion (Figure 1). It is generally recognized that corroded cast iron retains some of its original strength, but the extent to which cast-iron pipe may corrode underground and still retain sufficient strength to withstand the pressures commonly used in water- and gas-distribution systems has not previously been estimated.

In order to evaluate the residual strength of corroded cast-iron pipe, the samples of pipe that had been removed from the more corrosive soils after the longer periods of exposure were subjected to hydraulic pressures. The screwcap on one end of each sample was replaced by a similar cap in which a fitting had been inserted and the pipe section connected by copper tubing to a hand pump of suitable capacity. The pressure was increased at the rate of approximately 10 (lb/in.^{2})/sec until failure of the pipe occurred or the maximum pressure of 500 lb/in.^{2} was attained. After the application of hydraulic pressure, the corrosion products were removed and the condition of the specimens was evaluated in the usual manner. The hydraulic pressures applied to the sam-

TABLE 1—Properties of the Soils at the Test Sites

TEST SITES									COMPOSITION OF WATER EXTRACT (Milligram Equivalent per 100 g of Soil)						
Environment and Soil Type	Soil	Location	Aeration [a]	Moisture Equivalent	Apparent Specific Gravity	Resistivity at 60° F (15.6° C)	pH	Total Acidity [b] (Milligram Equivalent per 100 g of Soil)	Na+K as Na	Ca	Mg	CO_3	HCO_3	Cl	SO_4
				Percent		Ohm-cm									
INORGANIC OXIDIZING SOILS															
Cecil clay loam	53	Atlanta, Ga.	G	33.7	1.60	17,800	4.8	5.1	....	....	....	....	....	....	....
Hagerstown loam	55	Loch Raven, Md.	G	32.0	1.49	5,210	5.8	10.9	....	....	....	....	....	....	....
Susquehanna clay	62	Meridian, Miss.	F	34.6	1.79	6,920	4.5	12.0	....	....	....	....	....	....	....
Chino silt loam	65	Wilmington, Calif.	G	26.4	1.41	148	8.0	A	7.65	12.40	2.20	0.00	1.30	6.05	16.90
Mohave fine gravelly loam	66	Phoenix, Ariz.	F	16.5	1.79	232	8.0	A	6.55	0.51	0.18	.00	0.73	2.77	2.97
INORGANIC REDUCING SOILS															
Sharkey clay	61	New Orleans, La.	P	30.8	1.78	943	6.8	4.9	0.73	0.68	0.33	0.00	0.71	0.10	0.91
Docas clay	64	Cholame, Calif.	F	41.1	1.88	62	7.5	A	28.10	2.29	.76	.00	.89	28.80	.26
Lake Charles clay	56	El Vista, Tex.	VP	28.7	2.03	406	7.1	5.1	3.12	0.69	.47	.00	.80	1.59	3.04
Merced silt loam	70	Buttonwillow, Calif.	F	24.7	1.69	278	9.4	A	8.38	.38	.22	.02	1.87	1.12	5.57
ORGANIC REDUCING SOILS															
Carlisle muck	59	Kalamazoo, Mich.	VP	43.6	....	1,660	5.6	12.6	1.03	3.08	2.70	0.00	0.00	3.47	1.04
Muck	58	New Orleans, La.	P	57.8	1.43	712	4.8	15.0	2.03	2.23	1.29	.00	.00	0.47	2.54
Rifle peat	60	Plymouth, Ohio	P	43.4	1.28	218	2.6	297.4	2.91	10.95	2.86	.00	.00	.00	56.70
Tidal marsh	63	Charleston, S.C.	VP	46.7	1.47	84	6.9	14.6	33.60	6.85	4.00	.00	.00	12.70	36.60
CINDERS															
Cinders	67	Milwaukee, Wis.	VP	....	....	455	7.6	A	0.77	3.03	0.53	.00	.55	0.08	2.89

[a] G, good; F, fair; P, poor; VP, very poor.
[b] A, alkaline reaction.

TABLE 2—Composition of the Materials

MATERIAL	Identification	Form	Nominal Width or Diameter	Length	Thickness	C (Total)	Si	Mn	S	Cr	Ni	Cu
			In.	In.	In.	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Plain cast iron	A	Pipe	1.5	13	0.250	3.22	2.19	0.91	0.12	....	....	....
Low-alloy cast iron	B	Pipe	1.5	13	.250	3.28	2.09	.83	.12	....	1.27	0.32
Low-alloy cast iron	C	Pipe	1.5	13	.250	3.24	2.08	.80	.12	....	1.71	.98
Low-alloy cast iron	NC	Plate	2.5	14	.5	2.80	2.03	....	....	....	2.08	1.10
Low-alloy cast iron	N	Plate	2.5	14	.5	2.75	2.00	....	....	....	3.10	....
Low-alloy cast iron	D	Pipe	1.5	13	.250	3.21	2.11	.72	.12	....	3.32	....
High-alloy cast iron	E	Pipe	1.5	10	.250	2.98	2.13	1.00	....	2.61	15.00	6.58

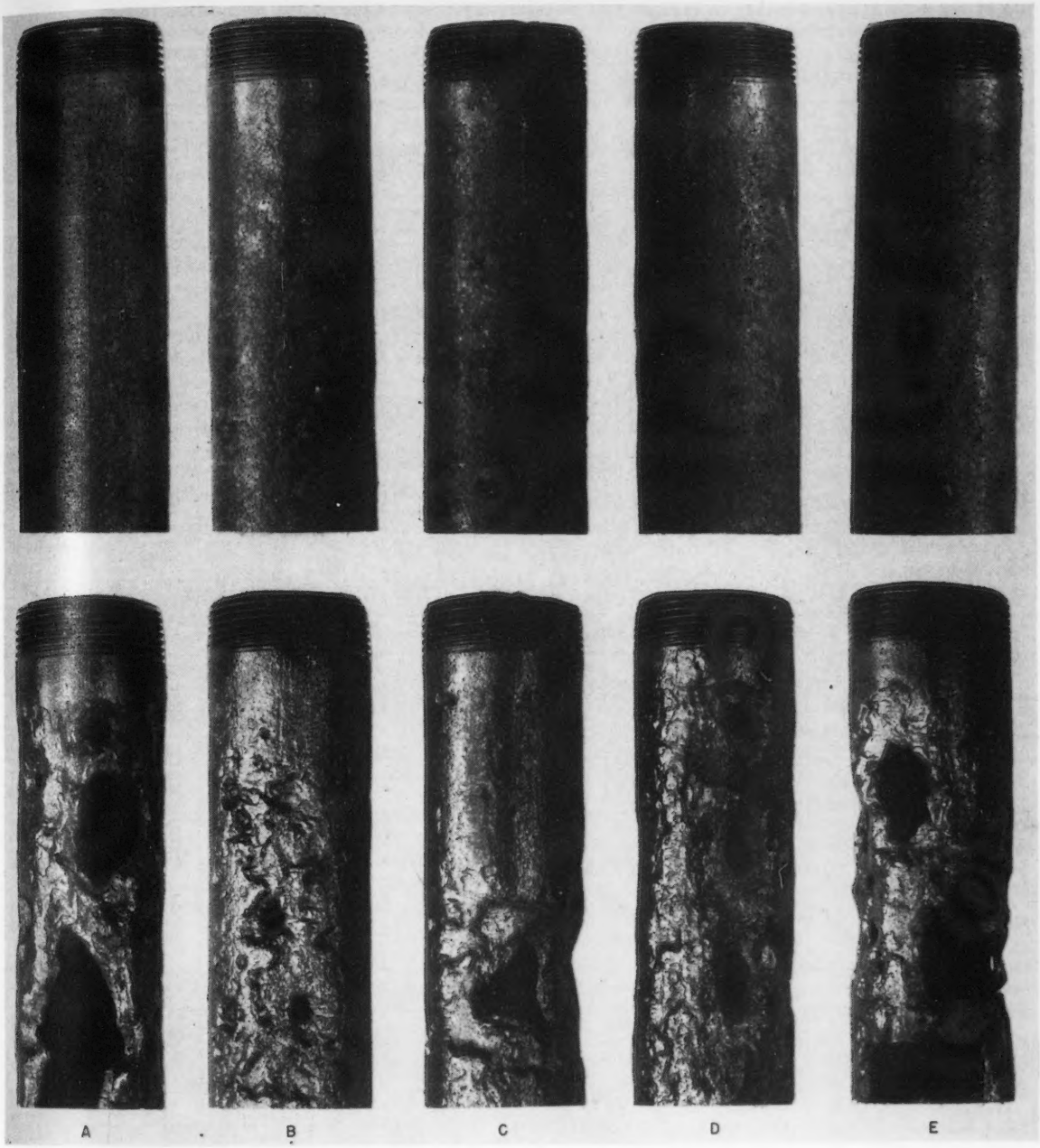

Figure 1—Condition of cast iron exposed to highly corrosive soils before (top row) and after (bottom row) removal of the corrosion products. Exposure 11 years, approximately. A, Lake Charles clay at El Vista, Tex.; B, Muck, at New Orleans, La.; C, Tidal marsh at Charleston, S. C.; D. Docas clay at Cholame, Calif.; Merced silt loam at Buttonwillow, Calif.

ples and the number of perforations in the samples after being cleaned are given in Table 5.

The data in Table 5 show that most of the specimens withstood a maximum pressure of 500 lb/in.^{2}, although removal of the corrosion products revealed numerous holes of various diameters. The few low values of bursting pressure given in the table probably should not be taken as accurately measuring the strength of the corroded pipe because of oxidation and probable damage to the pipe in handling and shipping. Hence it is reasonable to conclude that cast-iron pipe in an advanced stage of graphitic corrosion is able to withstand the minimum pressure required of class 150 pipe.

In considering the data of Table 5, it is important to note that the pipe samples were subjected to hydraulic pressure from six months to a year after removal from the test sites. Inspection of the samples showed that during this interval some oxidation of the corrosion products occurred, as was indicated by

TABLE 3—Losses in Weight and Maximum Pitting of Plain and Alloy Cast Irons

SOIL		EXPOSURE		LOSS IN WEIGHT							MAXIMUM PENETRATION						
				Cast-Iron Pipe					Cast-Iron Plate		Cast-Iron Pipe					Cast-Iron Plate	
Number	Type	For All Materials Except E[a]	For Material E Only[b]	Plain Cast Iron A	1.27 Ni 0.32 Cu B	1.17 Ni 0.98 Cu C	3.32 Ni D	15.0 Ni 6.6 Cu 2.6. Cr E	2.08 Ni 1.10 Cu NC	3.10 Ni N	Plain Cast Iron A	1.27 Ni 0.32 Cu B	1.71 Ni 0.98 Cu C	3.32 Ni D	15.0 Ni 6.6 Cu 2.6 Cr E	2.08 Ni 1.10 Cu NC	3.10 Ni N
INORGANIC-OXIDIZING SOILS																	
53	Cecil clay loam	Years 4.9 7.2 8.6 10.8 ...	Years 2.0 5.4 7.4 9.3 14.3	Oz/ft² 3.2 5.1 6.0 5.9 ...	Oz/ft² 3.9 4.2 6.3 4.7 ...	Oz/ft² 3.5 4.9 5.7 5.5 ...	Oz/ft² 3.5 4.6 5.9 5.1 ...	Oz/ft² 1.2 0.7 .7 1.4 1.2	Oz/ft² 3.3 4.1 4.4 3.2 ...	Oz/ft² 3.0 3.2 3.4 3.7 ...	Mils [c]179+ 131 194+ 145 ...	Mils 124 131 129 136 ...	Mils 144 122 215+ 132 ...	Mils 136 120 139 120 ...	Mils 30 36 51 33 44	Mils 133 138 148 149 ...	Mils 120 131 144 163 ...
55	Hagerstown loam	5.1 7.0 8.7 11.1 ...	2.0 5.4 7.4 9.3 14.3	2.2 3.8 5.1 3.5 ...	2.5 3.5 4.8 3.8 ...	2.6 3.8 4.8 4.1 ...	2.6 4.2 4.5 4.3 ...	0.8 .6 .7 4.3 1.1	1.6 2.8 3.4 3.8 ...	2.1 3.1 3.1 4.1 ...	110 108 116 132 ...	114 118 115 158 ...	123 114 117 114 ...	96 115 126 157 ...	30 37 41 34 51	110 123 148 147 ...	113 119 140 171 ...
62	Susquehanna clay	4.9 7.2 8.7 10.9 ...	1.0 5.4 7.4 9.3 14.3	3.6 6.7 8.7 5.6 ...	3.5 5.1 9.0 6.5 ...	3.8 4.9 7.7 6.7 ...	2.6 5.1 8.5 5.4 ...	1.7 1.1 1.0 2.7 2.3	3.1 1.8 5.8 4.9 ...	2.5 4.5 5.9 5.2 ...	53 76 74 117 ...	77 89 110 199+ ...	112 122 120 180+ ...	104 135 175+ 223+ ...	43 49 37 53 60	94 89 113 132 ...	76 84 139 144 ...
65	Chino silt loam	5.0 7.2 8.8 10.9 ...	2.0 5.4 7.4 9.3 14.3	8.6 5.6 11.9 3.4 ...	7.7 3.1 6.6 3.0 ...	9.9 3.4 5.5 2.6 ...	7.0 2.3 6.0 3.7 ...	1.5 3.0 2.0 2.6 3.1	7.9 4.9 8.6 7.4 ...	8.2 4.2 9.7 8.6 ...	113 109 121 111 ...	148 114 117 114 ...	129 123 154 112 ...	157 107 197+ 185+ ...	26 42 42 35 59	110 110 [illegible] 104 ...	100 102 132 158 ...
66	Mohave fine gravelly loam	5.0 7.2 8.8 11.0 ...	2.0 5.4 7.4 9.3 14.3	6.2 29.6 25.6 5.3 ...	8.2 27.5 28.5 6.8 ...	9.3 27.8 [e]D 9.5 ...	8.3 28.6 D 9.4 ...	3.1 3.0 3.5 3.3 7.6	6.6 29.9 21.7 9.0 ...	[d]10.2 27.7 22.4 8.6 ...	67 209+ 189+ 160+ ...	80 227+ 141 142 ...	80 250+ 250+ 143 ...	80 250+ 250+ 115 ...	26 36 38 40 54	[illegible] 227 [illegible] [illegible] ...	[d]80 221 230 147 ...
INORGANIC-REDUCING SOILS																	
56	Lake Charles Clay	4.9 7.2 8.7 10.9 ...	2.0 5.4 7.4 9.3 14.3	6.5 19.4 19.4 19.3 ...	3.9 20.5 18.3 21.7 ...	4.1 20.9 20.8 20.3 ...	2.9 16.3 20.7 19.4 ...	3.3 4.6 9.4 14.6 17.3	4.8 18.8 15.7 26.6 ...	7.3 16.2 15.6 27.2 ...	124 202+ 188+ 250+ ...	96 210+ 250+ 250+ ...	64 188 208+ 213+ ...	50 179 250+ 192+ ...	42 32 53 58 72	111 198 220 210 ...	120 183 231 248 ...
61	Sharkey clay	4.9 7.2 8.7 10.9 ...	2.0 5.4 7.4 9.3 14.3	6.8 6.6 7.9 4.0 ...	5.7 5.4 7.8 3.7 ...	5.6 5.3 5.6 3.4 ...	5.2 5.1 6.2 3.5 ...	0.3 1.8 1.7 2.3 5.2	3.4 5.0 4.9 3.1 ...	3.4 4.7 4.1 2.9 ...	78 93 96 85 ...	122 108 136 172 ...	112 110 133 122 ...	104 116 122 132 ...	36 39 30 36 58	84 113 121 139 ...	96 107 128 104 ...
64	Docas clay	5.0 7.2 8.8 11.0 ...	2.0 5.4 7.4 9.3 14.3	19.7 22.1 24.2 25.1 ...	20.4 20.4 24.7 14.8 ...	18.7 17.2 14.5 23.6 ...	14.4 9.5 15.0 21.1 ...	4.4 3.1 5.8 12.8 4.8	15.5 23.4 37.5 26.5 ...	15.8 23.1 35.7 25.0 ...	151 242+ 240+ 214+ ...	187+ 237+ 185+ 213+ ...	210+ 229+ 161 206+ ...	226+ 175+ 189+ 250+ ...	28 27 40 74 34	138 206 220 178 ...	138 191 218 195 ...
70	Merced silt loam	5.0 7.2 8.8 11.0 ...	2.0 5.4 7.4 9.3 14.3	7.5 35.3 34.4 D ...	4.8 34.4 D D ...	4.2 31.4 D D ...	3.7 D D D ...	... ...	7.0 26.8 25.4 37.2 ...	7.6 26.1 25.5 38.1 ...	104 250+ 217 250+ ...	106 250+ 250+ 250+ ...	90 250+ 250+ 250+ ...	93 250+ 250+ 250+ ...	... ...	101 254 268+ 268+ ...	107 240 255+ 265+ ...
ORGANIC-REDUCING SOILS																	
58	Muck	4.9 7.2 8.7 10.9 ...	2.0 5.4 7.4 9.3 14.3	6.8 6.4 6.8 5.4 ...	4.4 4.8 7.6 4.3 ...	3.5 4.2 5.8 4.5 ...	1.4 6.1 6.0 3.7 ...	0.8 4.9 8.6 9.9 10.0	3.6 4.8 5.2 5.3 ...	3.2 5.1 5.5 6.7 ...	106 160+ 116 151+ ...	140 171+ 121 190+ ...	109 168+ 82 168+ ...	144 168+ 100 136 ...	50 34 58 53 54	118 148 123 206 ...	119 139 118 143 ...
59	Carlisle muck	5.1 7.1 8.7 11.1 ...	2.0 5.4 7.4 9.3 14.3	14.4 10.3 15.6 16.0 ...	13.3 8.3 11.3 15.5 ...	11.1 8.7 13.2 15.6 ...	7.6 9.1 11.1 15.4 ...	... 0.4 .6 .7 [f]1.3	5.4 8.7 9.0 16.0 ...	5.4 8.5 9.0 16.4 ...	89 81 76 107 ...	89 84 80 107 ...	111 78 86 103 ...	87 76 86 106 ...	... 14 28 26 [f]30	78 82 93 113 ...	80 89 92 128 ...
60	Rifle peat	5.1 7.1 8.7 11.1 ...	2.0 5.4 7.4 9.3 14.3	6.5 13.6 14.2 10.1 ...	2.0 12.1 13.8 16.8 ...	1.9 10.8 12.8 6.2 ...	3.5 11.8 14.9 7.3 ...	4.2 4.9 [d]1.3 10.0 11.6	4.4 10.4 11.7 8.0 ...	3.6 9.7 11.7 9.7 ...	52 71 66 71 ...	39 69 64 61 ...	32 72 54 65 ...	94 75 60 56 ...	24 80 [d]22 45 72	56 74 68 81 ...	66 78 65 79 ...
63	Tidal marsh	4.9 7.2 8.6 10.8 ...	2.0 5.4 7.4 9.3 14.3	3.8 5.9 4.5 4.3 ...	2.4 3.9 6.1 4.8 ...	2.3 4.8 4.6 3.6 ...	0.6 6.2 4.2 2.0 ...	0.6 .6 .7 1.6 1.5	[d]4.3 5.3 3.9 8.0 ...	[d]3.5 4.6 3.7 6.4 ...	99 111 55 92 ...	102 97 58 152+ ...	86 104 58 124+ ...	24 105 42 55 ...	22 16 55 32 30	[d]110 114 62 187 ...	[d]106 121 58 226 ...
CINDERS																	
67	Cinders	5.1 7.1 8.7 11.1 ...	2.0 5.4 7.4 9.3 14.3	D D D D ...	D D D D ...	D D D D ...	D D D D ...	17.6 38.4 24.3 D D	D D D D ...	D D D D ...	250+ 250+ 250+ 250+ ...	250+ 250+ 250+ 250+ ...	250+ 250+ 250+ 250+ ...	250+ 250+ 250+ 250+ ...	94 250+ 250+ 250+ 250+	250+ 250+ 250+ 250+ 250+	250+ 250+ 250+ 250+ 250+

[a] Average of 2 specimens removed at each of the 5- and 9-year periods. Average of 3 specimens removed at each of the 7- and 11-year periods.
[b] Average of 2 specimens removed from each site at each period.
[c] + indicates that 1 or more specimens contained holes due to corrosion.
[d] Data for 1 specimen only. The other specimen was missing.
[e] D. Specimens destroyed by corrosion.
[f] Data for 4 specimens.

slight increase in the volume of the corrosion products. Because oxidation is associated with loss in strength, it is reasonable to assume that if the samples had not been removed from the test sites, they would have withstood the applied pressure, even if they had been in a more advanced stage of corrosion. Instances of the loss in strength of graphitized cast-iron objects on exposure to air have been cited by Speller.[4]

In order to evaluate the strength of the corrosion products of cast-iron pipe undisturbed by removal from the test sites, 3-foot sections of 6-inch cast-iron pipe, closed at both ends, were buried at four of the Bureau test sites. The investigation was undertaken with the cooperation of the Cast Iron Pipe Research Association. Provision was made for applying hydraulic pressure to the pipe sections by means of a fitting inserted in the closure at one end of the pipe.

TABLE 4—Weight Losses of Pipe Specimens of Low-Alloy Cast Irons on a Relative Basis

(Relative to weight loss of plain cast iron A = 100)

Soil	Exposure Years	1.27 Ni 0.32 Cu Pipe B	1.71 Ni. 0.98 Cu Pipe C	3.32 Ni Pipe D
INORGANIC-OXIDIZING SOILS				
53	5	122	109	109
	7	82	96	90
	9	105	95	98
	11	80	93	86
55	5	114	118	118
	7	92	100	110
	9	94	94	88
	11	84	91	96
62	5	97	106	72
	7	76	73	76
	9	103	88	98
	11	116	120	96
65	5	90	115	81
	7	55	61	41
	9	55	46	50
	11	88	76	109
INORGANIC-REDUCING SOILS				
66	5	132	150	134
	7	93	94	97
	9	111	136	136
	11	117	179	177
56	5	60	63	45
	7	106	108	84
	9	94	107	107
	11	112	105	101
61	5	84	82	76
	7	82	80	77
	9	98	71	78
	11	92	85	88
64	5	104	95	73
	7	92	78	43
	9	102	60	62
	11	99	94	84
ORGANIC-REDUCING SOILS				
58	5	65	48	20
	7	75	66	95
	9	112	85	88
	11	80	83	68
59	5	92	77	53
	7	81	84	87
	9	72	85	71
	11	97	98	96
60	5	31	29	54
	7	89	79	87
	9	97	90	105
	11	67	61	72
63	5	63	61	16
	7	66	81	105
	9	136	102	93
	11	112	84	46

According to the plan of the test, a pressure of 400 lb/in.^{2} is applied to the pipe sections at approximately 2-year intervals until rupture occurs, at which time the section will be removed and the extent of corrosion evaluated. As none of the pipe sections has failed as yet to withstand the applied pressure, the test is necessarily incomplete. However, the data obtained to date in certain of the soils provide significant information on the strength of corroded cast-iron pipe under normal conditions of exposure.

In Table 6 are shown the number of years during which the pipe sections have withstood the applied pressure. For comparison, the condition of similarly exposed specimens of cast-iron pipe, as indicated by the maximum and average penetration, is also shown. The data reported for site 70 is especially significant. Although one of the control specimens was perforated within six years, the 3-foot section has withstood the applied pressure for 24 years, during which time it would be expected to be converted almost entirely to corrosion products. Similarly, the development of a pit 302 mils in depth in six years on the control specimens in soil 118 indicates that the 3-foot sections, which withstood the applied pressure after 24 years of exposure, should also be in an advanced stage of corrosion.

6. Summary

This report contains the results of measurements of weight loss, maximum depth of pitting, and of hydraulic bursting pressure made on samples of nickel cast irons after exposure to different soil conditions. Additions of nickel up to 3 percent significantly reduced the initial corrosion of cast iron in poorly drained soils of low resistivity, but this advantage was not maintained for the duration of the exposure tests. Samples of austenitic cast iron containing 15 percent of nickel, together with chromium and copper, showed good resistance to corrosion in most of the soils, especially with respect to maximum depth of pitting.

With some exceptions, samples of severely corroded plain and low-alloy cast-iron pipe withstood a maximum hydraulic pressure of 500 lb/in.^{2} after exposure at the test sites for periods up to 11 years and storage in the laboratory for approximately one year. Because the effect of oxidation in the air is to weaken the layer of corrosion products, the observed values for hydraulic bursting pressure are probably to be considered minimum values. The results of incomplete field tests of the bursting pressure of undisturbed sections of plain cast-iron pipe are in good agreement with the results of the measurements made on the stored samples.

The direction of this program by Mr. K. H. Logan prior to his retirement in 1946 is acknowledged.

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TABLE 5—Hydraulic Bursting Pressures and Number of Perforations of Pipe Samples

Soil	Exposure Years	Sample	PIPE A		PIPE B		PIPE C		PIPE D	
			Bursting Pressure Lb./In.²	Number of Holes	Bursting Pressure Lb./In.²	Number of Holes	Bursting Pressure Lb./In.²	Number of Holes	Bursting Pressure Lb./In.²	Number of Holes
	7.2	a	350	2	500+	1	.....	.....	.....	.....
		b	500+	1	500+	1	.....	.....	.....	.....
56	8.7	a	500+	3	500+	1	500+	3	500+	2
		b	.....	.....	500+	1	.....	.....	500+	1
	10.9	a	500+	1	500+	1	.....	.....	.....	.....
		b	500+	5	500+	10	500+	6	500+	8
58	7.2	a	500+	1	500+	1	500+	1	500+	1
	10.9	a	500+	1	500+	1	500+	2	.....	.....
	7.2	a	500+	6	0	7	50	10	500+	3
		b	500+	5	200	5	150	6	.....	.....
64	8.8	a	425	4	500+	4	.....	.....	500+	1
	11.0	a	500+	2	500+	3	375	4	500+	2
		b	500+	10	.....	.....	225	6	500+	3
		c	.....	.....	.....	.....	.....	.....	350	7
	7.2	a	450	5	.....	.....	500+	3	.....	.....
		b	500+	2	.....	.....	0	6	0	7
66	8.8	a	500+	1	.....	.....	500+	6	275	3
		b	.....	.....	.....	.....	350	4	500+	5
	11.0	a	500+	1	.....	.....	.....	.....	.....	.....
	7.2	a	500+	5	0	14	500+	6	500+	7
		b	500+	4	0	11	0	12	0	14
70	8.8	a	.....	.....	500+	6	0	12	0	12
		b	.....	.....	425	8	500+	7	300	9
	11.0	a	500+	12	175	18	.....	.....	500+	9
		b	50	16	500+	6	.....	.....	.....	.....
		c	500+	11	.....	.....	.....	.....	.....	.....

TABLE 6—Condition of Cast-Iron Pipe Withstanding a Maximum Hydraulic Pressure of 400 lb/in.²

SOIL		SPECIMENS EXPOSED FOR MEASUREMENT OF WEIGHT LOSS AND PITTING				SPECIMENS EXPOSED FOR APPLICATION OF HYDRAULIC PRESSURE 400 LB./In.²	
No.	Type	Exposure Years	Wall Thickness Mils	Maximum Pit Depth Mils	Average Penetration Mils	Maximum Period of Exposure Years	Wall Thickness Mils
[a]15	Houston black clay	17.6	450	226	14.9	24	450
64	Docas clay	5.0	250	250+	30.4	12.5	450
70 (23)	Merced silt loam	6.2	450	450+	58.4	24	450
[a]118	Niland gravelly sand	5.9	450	302	49.3	24	450

[a] See references 2 and 3 for properties of the soils.

Topic of the Month

Aluminum Coverings for Thermal Insulation

By HARRY W. FRITTS*

ALUMINUM sheet and heavy foil have been used for over 20 years as a covering for thermal insulation. Since World War II, these products have become standard covering material for this service. With the modern trend toward outdoor construction, especially in the chemical, petrochemical and petroleum industries, it is increasingly important to protect thermal insulation with an easily applied, low cost, corrosion-resistant material. Figure 1 shows a typical application of aluminum sheet for this purpose.

Aluminum alloys have a number of special advantages. First, they are readily available in the forms required at a moderate cost. Normally, alloy 3S is used for this service, although other aluminum alloys not containing copper as an alloy ingredient also are suitable. Aluminum alloy sheet is light (approximately ⅓ the weight of ferrous materials of the same gauge) thus making installation easier and less costly. Fasteners or bands of aluminum, stainless steel, galvanized or cadmium plated steel may be used. Monel, copper, or lead fasteners should not be used because of the danger of galvanic corrosion of aluminum. In the case of pipe line covers, a number of proprietary adhesive tapes have been employed.

Normally, aluminum does not require painting. It has excellent weathering properties and is resistant to most of the corrosive elements commonly encountered in industrial atmospheres. Aluminum is a good reflector of radiant heat. This can be an important factor in reducing vapor losses in storage tanks. Figure 2 illustrates the use of aluminum insulation coverings on a large petroleum storage tank. Aluminum coverings dress up a plant and give it a clean, well-kept look.

If the special limitations of any material of construction are taken into account its usefulness will be lengthened. In the presence of moisture many common insulating materials either have an alkaline leach or will support electrochemical corrosion because of the development of concentration cells. Either or both of these conditions can cause corrosion of aluminum alloys.

If the thermal insulation is dry, aluminum sheet can be installed safely with any of the standard insulating materials. Where moisture is anticipated, it is good practice to incorporate a barrier which will prevent contact between aluminum and the moist insulation. Paint coatings or fully impregnated tar papers are useful as barriers. There are a number of insulating materials which are innocuous to aluminum alloys even when wet. These include the borosilicate glass and calcium silicate type insulating materials, among others. Aluminum-alloy sheathed insulation in packaged units is available for covering pipe.

Service histories on aluminum coverings for thermal insulation show that installations have been in service for over 20 years in industrial atmospheres and are still performing satisfactorily. Experience has shown that aluminum sheet is superior to other common coverings in sea coast and industrial atmospheres, even those contaminated with many types of chemical fumes and dusts.

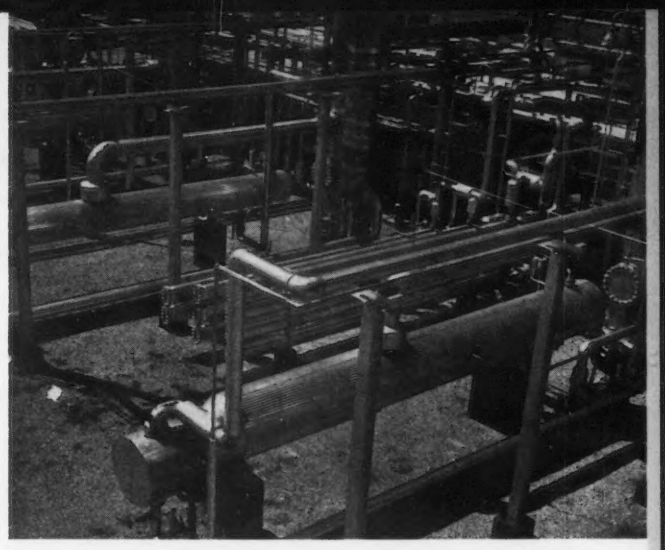

Figure 1—The insulation on the pipes, heat exchangers and towers in this gasoline plant is well protected by aluminum.—(Photo courtesy Pittsburgh Corning Corp.)

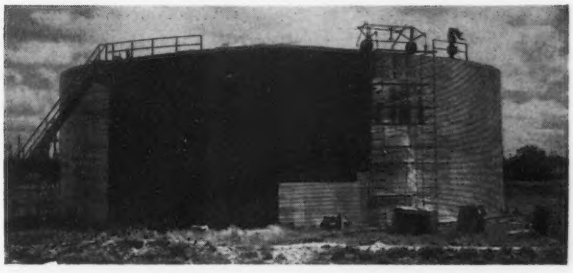

Figure 2—Aluminum sheet for covering thermal insulation of a large petroleum storage tank.—(Photo courtesy Tank Insulators, Inc.)

* Sales Development Division, Aluminum Company of America, New Kensington, Pa.

NACE News

Forty-First NACE Section Petitions for Charter

HOUSTON SECTION OFFICERS—Shown above as they made plans for their first meeting are the newly elected officers of Houston Section. From left to right they are George Hall, Thornhill-Craver Co., secretary-treasurer; Alvan E. Richey, Cathodic Protection Service, vice-chairman; Joseph A. Caldwell, Humble Oil & Refining Co., chairman and L. G. Sharpe, Napko Paint & Varnish Works, trustee, all of Houston.

Caldwell Heads Houston Section Effective June 8

With 250 of the more than 400 members voting, Houston Section members elected new officers for the coming year. Joseph A. Caldwell, Humble Oil and Refining Co. was elected chairman; Alvan E. Richey, Cathodic Protection Service, will be the new vice-chairman; George D. Hall, Thornhill-Craver Co., secretary-treasurer and L. G. Sharpe, Napko Paint and Varnish Works, was elected trustee. New officers are to be installed at the June 8 meeting.

The new officers have had considerable experience in NACE activities. Mr. Caldwell served as vice-chairman of the Section last year. He is the incumbent chairman of T-1D Sour Oil Well Corrosion, is a member of other NACE technical committees, is a representative on the Houston Engineers' Council and is a charter member of the Houston Section.

Mr. Richey, new vice-chairman, is co-chairman of the Section's Corporate Membership Committee drive, is general chairman of the 1955 meeting of the South Central Region to be held in Houston. He is also active in American Chemical Society activities.

Mr. Hall, who becomes secretary-treasurer, has served as arrangements chairman during the past year.

Mr. Sharpe, newly elected trustee, has been prominent in NACE, both in the Houston Section and on a national scope. In section activities, he served as secretary - treasurer, vice - chairman and chairman. He is the author of "Economic Considerations of Pipe Line Corrosion Control," a technical paper presented at the South Central Region meeting held in Tulsa last October, and which was again presented at the 1954 Annual Conference held in Kansas City last March. He was chairman of the Pipe Line Corrosion Symposium at the annual Conference held in Galveston in 1952. He is also a member of other technical committees.

Section members will attend the annual social meeting terminating the section year on June 8 at Diamond Alkali park. A program of swimming, dancing, beer and barbecue and a plant tour are on the agenda.

Teche Section Officers Installed Recently

New officers installed recently by Teche Section are: J. H. Booksh, Jr., United Gas Corp., New Iberia, chairman; Vernon Sibille, Superior Oil Co., Lafayette, La.; Ralph J. Rice, Tretolite Co., Lafayette, secretary-treasurer; Gus Vogler, Allen Cathodic Protection Co., Lafayette, trustee.

Organization Meeting Is Held at Knoxville

An organization meeting of NACE members at Knoxville, Tenn., April 29 resulted in the temporary organization of the East Tennessee Section of NACE. A petition for recognition as a section has been forwarded. The section is the forty-first organized.

Temporary officers were elected as follows: Anton de S. Brasunas, University of Tennessee, Knoxville, chairman; Charles F. Fisher, Jr., Knoxville; James L. English, Oak Ridge.

Permian Section Plans Booth at Oil Show

Corrosion "sleuths" in the Permian Basin heard an investigator of a different nature at their April 12 meeting. Featured speaker at the April 12 meeting held in the Cave Room, the Lincoln Hotel, Odessa, was John P. Mansfield of the Western Co., Midland. Mr. Mansfield spoke on the confidence racket. He is a veteran of 11 years' service with the Federal Bureau of Investigation.

A report to the group on the NACE Conference in Kansas City was presented by Tom Newell, Section Trustee. The section is making plans for a booth at the Oil Show which will be held in Odessa this fall. Tom Smith and Ed Ray are in charge of the arrangements. Also on the program was a short film produced by the Reynolds Metals Co. on the mining, manufacturing and uses of aluminum.

It was announced that the next speaker to address the section will be H. L. Bilhartz of the Atlantic Oil and Refining Co., Dallas.

Slag used in a stone trickle filter was attacked by the effluent from a chemical plant and had to be replaced.

HALF-YEAR MEMBERSHIPS IN NACE

Applications for active membership in the National Association of Corrosion Engineers received at the Central Office after July 1st, may, at the option of the applicant, be for the last half of the calendar year—July-December inclusive, with dues of $5.00.

- **This half-year membership entitles the member to receive copies of CORROSION magazine for the months of July-December, inclusive and all the benefits of the association after July 1.**
- **If you are interested in membership in NACE write for an application for membership or see the NACE Section secretary if an NACE section operates in your city.**
- **Applications for membership for the whole of the calendar year will be accepted also and copies of CORROSION supplied for the whole year as long as the supply of back issues lasts.**

Write to A. B. Campbell, Executive Secretary NATIONAL ASSOCIATION OF CORROSION ENGINEERS, 1061 M & M Bldg., Houston 2, Texas.

Pipe Line Coatings and Application Covered at Shreveport April 20

R. L. Bullock, Interstate Oil Pipe Line Co., Shreveport, presented a talk and gave a narration accompanying a motion picture film on pipe line coatings and their application to members of Shreveport Section April 20. Mr. Bullock described early types of coatings, the history of applications, new types of coatings and projected coatings of the future. Several samples of the newer coatings, such as extruded butyrates available for inspection. The film was titled "Interstate's Coating Procedures."

Plans for the May meeting which will feature a round table discussion were reviewed and some planning was done for the annual September fish fry of the section. There will be a three-months' period without meetings after the May meeting.

Glassed Steel Is Topic At San Francisco Meeting

Members of the San Francisco Section attending the March 30 meeting heard B. G. Staples, research chemist, The Pfaudler Co., discuss the design, production, chemical resistance and maintenance of glassed steel equipment. He discussed the broad application of glassed steels in various acidic environments and pointed out the importance of the recently developed alkaline resistant glass.

With the aid of slides, he explained the various laboratory techniques for evaluating physical and chemical properties of glassed steel. Mr. Staples took and active part in the development of Teflon schielded gaskets, tantalum repair plugs and in the evaluation of the chemical durability of glass. A discussion period followed the talk.

The meeting was held at the Alouette restaurant with 18 members and 10 guests present.

Sprayed Metal Systems Scheduled Topic for St. Louis May 25 Session

Corrosion Resistance of Sprayed Metal Coatings was the scheduled subject for the May 25 meeting of Oklahoma City Section. Walter B. Meyer, president of the St. Louis Metallizing Co., speaker told of the merits of composite coatings consisting of sprayed metals impregnated with various vinyl, chlorinated rubber and phenol materials. The speaker, with almost 20 years' experience in the metallizing field, is an NACE member.

The April 27 dinner meeting at Oklahoma City YWCA heard George W. Cupit, Dan Cu Chemical Co., Oklahoma City, described a method by which 1010 steel can be given a hardness within 6 points of that of a diamond and how it retains this hardness. Eighteen persons heard this material, Chemic Steel, described.

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Additional copies of CORROSION are available at 50c each to NACE members and $1 each to non-members.

Atlanta Section Names New Slate of Officers

New officers have been elected by Atlanta Section as follows: Raymond F. Trapp, Midwestern Pipeline Products Co., Chamblee, Ga., chairman; George M. Jeffares, Plantation Pipe Line Co., Atlanta, vice-chairman; Douglass T. Rosselle, Southern Bell Telephone & Telegraph Co., Atlanta, secretary-treasurer.

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Responsible publications and businesses may obtain permission to reprint technical material published by NACE on application to the association.

Panel Answers Questions At Corpus Christi April 27

A panel of seven answered questions from the floor at the April 27 dinner meeting of Corpus Christi Section at Hotel Nueces, Corpus Christi. Thirty-three were present.

Members of the panel were Hugh Wilbanks, Gas Dept., City of Corpus Christi; Charles Ward, Magnolia Pipeline Company; Elbert Rankin, Republic Pipeline Company; E. V. Kunkel, Celanese Corp., Bishop, Texas; John W. Nee, Briner Paint Mfg. Co., Corpus Christi; Frank I. Dorr and Walter W. Mach, Cathodic Protection Service, Houston.

FEDERATED METALS OFFERS NEW REPORT: "CATHODIC PROTECTION WITH ZINC ANODES"

Federated's Corrosion Advisory Service offers you, without obligation, a new report titled, "Cathodic Protection With Zinc Anodes," prepared by Ebasco Services Inc. for the American Zinc Institute. This new publication reports additional findings obtained since the first report was issued in November, 1951. In it you will find important and valuable facts that have influence on the proper applications of zinc anodes. Use coupon below for your free copy.

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Kanigen Process Described To Chicago Section

The Kanigen Process, a method of depositing chemically a non-porous nickel coating on steel was the scheduled topic of discussion at the April 20 meeting of Chicago Section. Richard W. Landon, head of the licensing section of the Kanigen Division, General American Transportation Corp., was speaker.

Besides the voting for officers the May 20 meeting program included a round table discussion on corrosion problems.

Jacksonville Section Names 1954 Officers

Officers elected for 1954 by Jacksonville, Fla. Section are as follows: Charles Chapman, Virginia-Carolina Chemical Corp., Nichols Fla., chairman; H. E. Alexander, Dozier & Gay Paint Co., Jacksonville, vice-chairman; T. W. Bostwick, City of Jacksonville, secretary-treasurer.

Jacksonville and Miami Sections scheduled a joint meeting May 14 at Miami.

How CORROSION Is Indexed

Annually, in December issue, a cross-referenced tabular topical index of the material published in the Technical Section is published. An alphabetical subject index will be published in the December, 1954 issue.

Annually, in December issue, an alphabetical author index is published.

Annually, in December, a tabular index to the Corrosion Abstract Section is published.

Monthly, technical articles published in Corrosion are abstracted in the Corrosion Abstract Punch Card Service.

5 Year Index, 1945-49, consisting of a cross-referenced tabular topical index and an alphabetical author index was published in the December, 1950 issue of Corrosion.

Bibliographic Surveys of Corrosion—Corrosion Technical Material is indexed in the NACE's Bibliographic Surveys.

Corrosion is regularly indexed by Engineering Index.

10-year Index, 1945-54—In preparation and scheduled to appear early in 1955 is a 10-year index to the Technical Material published in Corrosion. It will consist of a cross-referenced tabular topical index, an alphabetical subject index and an alphabetical author index.

No indices of other sections of Corrosion are prepared by NACE.

All indexing is done, as far as practical, according to the NACE Abstract Filing System Index, which is used for NACE Abstract Punch Cards and the biennial Bibliographic Surveys of Corrosion.

POSITIONS WANTED and AVAILABLE

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Metallurgical Mining Engineer—Law degree also, seeks suitable executive, administrative position. Registered professional engineer, experienced corrosion, metallurgy, mining, production, research, government specifications, technical report interpretation. Presently self-employed. Available immediately. Write CORROSION Box 54-13.

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ARTHUR C. MENGEL

Arthur C. Mengel, chief chemical engineer for the American Locomotive Company, died suddenly March 20 at his home in Ballston Lake, N. Y. He was chairman of the Schenectady-Albany-Troy Section of NACE at the time of his death.

He joined American Locomotive Company in 1915 and held various positions in the company, becoming chief chemist at Schenectady in 1935. He was active in his company's changeover from steam engine to Diesel engine production and in industrial problems including corrosion prevention and new cleaning methods.

Selection of Coatings Discussed at San Diego

John I. Richardson, Amercoat Corp., discussed Guideposts for the Selection of Protective Coatings at a meeting of San Diego Section April 7. Fifteen members and 13 guests were present. His illustrated talk was followed by an open discussion.

Picnic Scheduled by North Texas Section May 14

North Texas Section planned a picnic at White Rock Lake beginning at 5 pm May 14. Wives and children attended.

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BOOK REVIEWS

German Iron and Steel Association Yearbook, 1954. (In German). 5⅝ x 8⅛ inches, 412 pages, flexible cloth. Verein Deutscher Eisenhuttenleute, Dusseldorf, Postfach 2507, Germany. Numerous categories of information about the personnel, organization, publications and activities of the VDEh are included. An alphabetical and a geographical list of members is part of the book.

Lead Handbook for the Chemical Process Industries. 44 pages, 8½ x 11 inches, paper cover. 1954. Federated Metals Division, American Smelting & Refining Co., 120 Broadway, New York 5, N. Y. Free.

A well-designed and carefully printed book outlining in some detail the principal mechanical and chemical characteristics of lead as a material for construction in the chemical industry. Considerable emphasis is laid on the corrosion uses of the material and tables of data are given showing the order of resistance of the material to different chemicals and combinations of chemicals. Ratings are keyed to temperatures, pressures, velocities and cyclic reconstitution of lead's corrosion-limiting surface layers.

After a general discussion of the reason lead is resistant to corrosives, the book successively discusses grades of lead, and the various sizes, thicknesses and shapes of fabricated material produced by Federated Metals.

Details of construction recommendations for lead linings, with diagrams of common applications for both sheet lead-lined and bonded lead-lined components are given.

A list of the chemicals and chemical processes with which lead is used is given and reaction of the material is graphically protrayed to sulfuric acid, temperatures, creep and velocity of sulfuric acid.

Non-Ferrous Foundry Metallurgy. 6 x 9¼, 497 pages, cloth. 1954. McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y. Per copy, $12.50.

This is a comprehensive collection of information on foundry metallurgy by British experts in the field. The first 156 pages of the book are devoted to a consideration of fundamental information on properties of liquid metals, solution of gases, solidification and other material of significance in casting. Succeeding chapters on technology, properties and testing of castings and casting alloys, all by British writers, cover what appears to be recommended practice in England and Europe with respect to castings. Most of the appended chapter references are to European sources.

Two references to corrosion are made, these consisting of brief discussions of the three principal classes of corrosion affecting castings. Reference to corrosion-resistant characteristics of some alloys, such as Hastelloy, for example are included, although these are not noted in the subject index. The writers believe castings are not as likely to be attacked by corrosion as wrought shapes.

The book is a well-rounded, illustrated, treatise on foundry principles, practices and techniques. Much data are tabulated.

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ATTENDING NORTHEAST REGION'S 1954 SPRING MEETING—(left to right) Front row, Frank E. Costanzo, retiring Pittsburgh Section chairman; Kempton H. Roll, Northeast Region chairman; P. F. George, program speaker; J. M. Bialosky, Pittsburgh past chairman; W. G. Renshaw, Pittsburgh vice-chairman; C. P. Larrabee, NACE director; N. P. Peifer, Pittsburgh past vice-chairman; L. G. Royston, Pittsburgh secretary; V. V. Kendall, Pittsburgh past vice-chairman and NACE director; Back row, Wallace Cathcart, Pittsburgh treasurer; F. J. LeFebvre, Metropolitan New York Section vice-chairman; George E. Best, Northeast region director; W. W. Binger, newly elected Pittsburgh chairman; W. F. Fair, Jr., past chairman Metropolitan New York Section and NACE director.

OFFICERS OF LEHIGH VALLEY SECTION—Officers of the recently-organized Lehigh Valley Section are shown at a meeting March 29 at Keystone Trail Inn, Allentown, Pa. They are, left to right: Seymoure "Ben" Frye, Bethlehem Steel Co., secretary-treasurer; Earl A. Erich, Atlas Mineral Products Co., Mertztown, Pa., chairman; G. Byron Godshall, Ingersoll-Rand Co., vice-chairman.

Nee Added to Corrosion Editorial Review Group

John W. Nee, Briner Paint Manufacturing Co., Corpus Christi, Texas has accepted appointment to the NACE Editoral Review Sub-Committee. As a member Mr. Nee will assist in reviewing prior to acceptance for publication manuscripts submitted for publication in Corrosion.

Southeast Region Has Spring Meeting May 6

The 1954 Spring Meeting of Southeast Region was held May 6 at Atlanta, Ga. Included in the day's program were three papers, a motion picture and a tour of the Lockheed Aircraft Corporation plant at Marietta, Ga. Forty attended the plant tour.

Papers presented were Comparative Cost of Magnesium Anodes vs Rectifiers on Coated Pipelines by Henry Allen, Allen Cathodic Protection Company, New Orleans; Fiberglas in Corrosion Control of Underground Pipe Lines by John B. Roadhouse, Owens-Corning Fiberglas Corp., Toledo, Ohio; Chemical Aspects and Uses of Saran by Stewart Blackmore, Dow Chemical Company, Detroit, Mich.

Barriers Are Discussed At New York Meeting

A symposium on Corrosion Prevention by Barriers was featured at the April 28 meeting of Metropolitan New York Section. The meeting was attended by about 65 members and 20 guests.

Topics presented and their discussers were:

Spray Plastic Barriers by D. M. Lamb, Technical Director, Better Finishes and Coatings, Inc., Newark, N. J. This pertained to cobweb and stripping type barriers.

Cold Applied Neoprene Linings was discussed by G. P. Kerns, vice-president in charge of sales for Gates Engineering Co., Wilmington, Del. with the assistance of the company's chief chemist, J. Deaconson.

Plastic Tapes as Corrosion Control Barriers, concerning vinyl and polyethylene tapes and their applications was discussed by Howard D. Segool, manager of specialized products, The Kendall Co., Chicago.

Volatile Corrosion Inhibitors, a discussion of crystal type and impregnated paper inhibitors was the topic of A. Black of the Product Application Division of Shell Oil Company.

Next meet of the section will be held in early fall.

W.F.Fair, Jr. Addresses Northeast Region's Pittsburgh Meeting

Some 100 corrosion engineers heard W. F. Fair, Jr., corrosion specialist of Koppers Co., Inc., speak about coal tar protective coating systems May 6 at Pittsburgh. The engineers attended the 1954 Spring Northeast Regional Corrosion Conference at Mellon Institute. Dr. Fair said there was a lack of uptodate information on coal tar coatings and coating combinations in some of the current "review" type publications. He detailed the importance, significance and value of certain properties of hot applied coatings and discussed specification testing.

He described in detail types of coal tar coatings currently available, how to select them for specified environments and their combination with other materials such as glass reinforcements, wrappers and the like. He cited the proved field performance during the past decade of combination coatings such as coal tar pitch emulsion over hot applied enamels, or a similar top coat over heavy-duty, high-consistency coal tar cut backs. He cautioned against indiscriminate use of non-bituminous primers without testing their compatibility with other materials to be applied.

This meeting was the second regional conference held at Pittsburgh. It opened with a tour of the Allegheny Ludlum Steel Corporation plant at Brackenridge, Pa. where steel making facilities and the research laboratory were visited.

Kempton H. Roll, Lead Industries Association, New York, chairman of the region spoke on the growth of the National Association of Corrosion Engineers after dinner at Hotel Webster Hall in Pittsburgh. He cited the addition of the Genessee Valley, Schenectady-Albany-Troy and Lehigh Valley Sections to Northeast Region during the year and noted that the region now has eleven sections, more than any other NACE region.

A sound film "Alsimag Custom Made Technical Ceramics," and an address by P. F. George, Dow Chemical Company, Midland, Mich. on the effect of alloying and impurity elements in magnesium alloy cast anodes were the concluding items on the program at Mellon Institute.

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Members of NACE may run a Positions Wanted classified advertisement annually in two consecutive issues of Corrosion without charge.

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All papers presented at annual meetings of NACE, except those not approved by mittee and Corrosion's editor, are pubthe association's editorial review comlished in Corrosion.

Corrosion Failures of Anchor Guy Rods Probed

Sour Crude Pipe Line and Tank Design and Operating Recommendations Are Drafted

Recommendations for design and operation of pipe lines and tanks in sour crude service which are likely to result in reduced corrosion damage have been proposed in reports submitted to T-2F on Internal Corrosion of Crude Oil Pipe Lines and Tanks (Formerly TP-18A). Two members of the committee, Lyle R. Sheppard, Shell Pipe Line Corp., and Jack P. Barrett, Stanolind Oil & Gas Co., collaborated in the report, which will be incorporated later in a formal report of the committee.

Construction Recommendations

These recommendations included:

Materials — Construction materials least susceptible to damage by crude oil should be selected and where metals of different solution potentials are used they should be separated from one another electrically.

Projections and crevices should be eliminated to prevent scale collection.

Gradients should permit draining of brine.

Oxygen admission should be restricted.

Dead oil spaces should be minimized.

Sump bottom tanks permit better removal of bottom sludges and water than flat bottom tanks.

Floating roof tanks reduce vapor phase corrosion.

Welded areas should be stress-relieved.

Operation—Their recommendations include the following items on operation:

Fill lines should be designed to impart a swirling motion.

Flushing roofs of fixed-type tanks with oil is beneficial.

Automatic valves to exclude oxygen are worthwhile.

Daily temperature fluctuations should be studied and operations adjusted where possible to minimize breathing in of oxygen.

Tanks should not be discharged to too low a level.

Tanks should handle the same grade of oil consistently and mixing of grades should be minimized.

Even, consistent flow rates of high velocity should be maintained.

Pipeline Design Considered

The report also makes recommendations concerning the design and operation of pipelines in crude service. These include:

Design should be such that normal flow will carry most scale and brine over high spots.

Drip and scale traps should be located wherever low points are created past which brine and scale will not be carried normally.

Projections and crevices inside the line should be avoided.

Scraper inlet and outlet traps should be provided.

Provisions for cleaning should be made for sections of line where velocity is reduced.

Scale and brine traps on the suction side of pumping stations lower internal corrosion of station equipment.

Dead oil space should be minimized.

Keep oxygen out of the lines as much as possible.

Turning pipe will lengthen its service life even though corrosion is not stopped.

Regular scraper programs are advisable.

Line velocities should be kept as high as possible.

Mixing of different grades of oil should be minimized.

Dead spaces, such as scraper trap barrels and river loop lines should be flushed regularly with oil.

Two Committees Shifted To T-2 on Pipe Lines

Two technical committees have been shifted from T-6 Protective Coatings to T-2 Pipe Line Corrosion, T-6D, now designated T-2G on Coal Tar Coatings for Underground Use and T-6L now designated T-2H on Asphalt Type, Pipe Coatings.

W. H. Stewart, Sun Pipe Line Co., chairman of T-2 said officers of the committees will be the same. T. F. P. Kelley, Mavor-Kelly Co., Houston is chairman and W. F. Fair, Jr., Koppers Co., Inc., Westfield, N. J. is vice-chairman of T-2G. R. J. Schmidt, California Research Corp., San Francisco is chairman and P. E. Reynolds, Pacific Gas & Electric Co., San Francisco vice-chairman of T-2H.

T-2J, a new committee, has been formed under T-2 and will study pipe wrapping materials. Clark A. Bailey, Johns-Manville Sales Corp., New York has been asked to take the chairmanship of the new group.

Ashbaugh Is Named

W. G. Ashbaugh, Carbide and Carbon Chemicals Co., Texas City has been elected vice-chairman of T-5 on Corrosion Problems in the Process Industries.

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Bacteria have been found that will digest phenols in effluent treatment plants.

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Iron had to be removed from effluent of a chemical plant before filtration because iron bacteria clogged the treatment plant.

Galvanic Currents Believed to Be Principal Cause

Corrosion failures in one year of steel anchor guy rods on Rural Electrification Adminstration transmission lines has been reported to T-4A on Effects of Electrical Grounding on Corrosion (Formerly TP-12). Several instances in which steel guy anchor rods were badly damaged by galvanic currents between the rods and copper clad ground rods were reported. Both rods were connected to the common neutral conductor of the distribution lines in order to ground the conductor most effectively.

Current as low as 50 milliamperes flowing from the anchor rod to earth may damage the rod sufficiently in a year to cause failure. Such a current would remove about a pound of metal in a year, and this, if concentrated over a small area of the rod, could cause serious damage.

Means of reducing the corrosion from galvanic currents in this type of installation were discussed, including plastic coatings of the anchor rods and installing insulators in the guy wire to break up circuits. Application of cathodic protection and changing the system to all-steel construction were considered.

The need for galvanizing was questioned because it was pointed out the zinc probably would be consumed in about two years anyway. Protection of an all-steel system cathodically would require only a very small percentage of the drain current that would be needed to protect a mixed steel and copper system.

The committee has considered previously the idea of using all steel grounding systems for power stations, substations and industrial plants. One member reported several all steel grounding systems had been installed at substations and one at a large steam electric station, most of which have been cathodically protected. Results of these test installations are expected to be communicated to the committee soon.

External corrosion of heating tubing imbedded in concrete floors to carry circulating hot water was discussed also. While greatest damage is believed to occur in transit system garages and other similar installations, it was pointed out considerable damage to home installations has been suffered also. Cathodic protection for home systems usually is by magnesium anodes while larger systems require rectifiers. Corrosion in the systems has been laid to stray current and galvanic action between steel and copper water pipes.

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Catalytic oxidation of fumes is considered to be a feasible air pollution control measure under certain conditions.

Varying Criteria Used by Companies in Protection of Underground Lead Cables

Varying criteria are used by operators of plant involving underground lead sheathed cable in determining whether or not corrosion is taking place. This conclusion was reached as a result of information supplied T-4B-2 on Cathodic Protection of Cable Sheaths during discussions held recently by the group.

One member described results of a procedure for reducing corrosion caused by deicing salts involving installation of electrically-heated street car switches and flushing ducts and installations. Current density was reduced from 90 to 30 ma/sq. ft. of cable in some instances. This member felt criteria should be related to current densities rather than structure-to-earth potentials, asserting his experience showed corrosion was unlikely when discharge was less than 10 ma/sq. ft. of cable.

Working limits reported by another company for plain lead sheath in stray current areas without cathodic protection were cable-to-earth potential of —.15 to —1.5 volts measured to a ground electrode of the same material as the cable sheath. He said that cable-to-earth potential in excess of —1.5 volts may lead to corrosion especially if potentials fluctuate. The —1.5 volt value is in the nature of an arbitary limit in stray current areas.

Another opinion was expressed concerned the relative merits of reference half cells. Widespread experience, one member asserted, demonstrated that the lead ground plate and lead chloride half cell are less reliable for measuring cable-to-earth potentials than copper-copper sulfate half cells. He said he made numerous measurements which showed a bright new piece of lead sheath immediately after cleaning will measure from —.55 to —.62 volts to a copper sulfate half cell, depending on the nature of the soil and composition of the sheath material. The applicable specific value between —.55 and —.62 volt for a given type sheath in a given soil has proved satisfactory as a reference zero in determining cable-to-earth potentials when lead ground plates are used.

This member said his company, using this criterion as a base strives for any negative cable-to-earth potential in non-stray current areas.

Working limits for satisfactory cable-to-earth potentials were given as follows by one member:

In non-stray current areas: Tape and wire armored, —.70 to —.85 volt to copper sulfate half cell.

Thermoplastic covered, —.15 volt to a permanently installed lead ground plate.

Jute protected, —.15 volt to permanent lead ground plate.

Polyethylene jacketed, —.15 volt to a permanent lead ground plate.

Whenever possible, it was pointed out, sheath current loss to earth is used as final criterion.

One member felt that while sheath current measurements for current loss or pickup are practical for long distance telephone cables they may not be useful on cable networks in congested city areas. Surveys by this member using a 12-inch plug pulled through line ducts are used as final criteria in congested areas. If a survey shows no current pickup from manhole to manhole then no corrosion trouble is indicated.

Cases were cited of cable-to-earth potential differences of .7 volts positive with no evidence of discharge of current to earth from cable. In applying cathodic protection this member found a shift in potential at the manhole of only —.2 volt cable-to-earth indicates a duct survey is necessary to check adequacy of protection.

Results of the committee's survey on Rectifier Ground Bed Design and Location indicate that most companies do not have set rules governing design and placement of rectifier ground beds or interference measurements. One member reported that while electrolysis committee work functions well in urban areas, the question of cooperative action in rural areas was unsettled.

In rural areas, he said, a company installing a subsurface structure may have knowledge of other nearby structures but may not be advised of structures added later. Field checks are necessary when cathodic protection is to be applied some time after installation of a system. Full cooperation consists of notifying other utilities before rather than after an installation is made.

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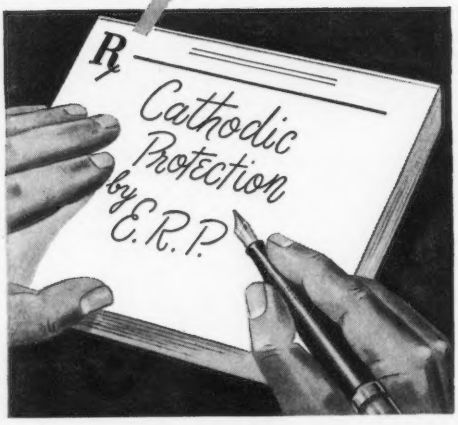

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Proposed Standard on Pipe Coating Conductance Is Now Being Circulated

A proposed standard on measuring leakage conductivity of pipe line coatings is circulating among members of T-2D on Standardization of Procedures for Measuring Pipe Coating Conductance (Formerly TP-17). If the draft is approved by committee members it will be forwarded as a report of the committee for publication.

The proposed standard, among other things, proposes and includes the following items:

Defines leakage conductance of a subsurface pipe line to be the unit current per unit area that will pass when a unit potential exists between the pipe and remote earth.

Test conditions are specified and a suggested test set up is detailed.

Instruments for the tests are specified and procedure is outlined.

Calculations for a general method are given in described formula form and an attenuation calculation method is given for certain conditions.

A section on reporting results is included.

An appendix to the proposed standard includes standard derivations of an approximate method and of the attenuation method.

Curves for establishing limits within which the general method may be used with acceptable accuracy are given.

Suggested recording forms are given.

W. E. Huddleston, Huddleston Engineering Co., Bartlesville, Okla., chairman of the committee reports that the committee believes the revised draft represents current best thinking on the problem of measuring pipe coating conductance. Mr. Huddleston says that use of leakage conductivity criteria in coating specifications and state code requirements, as well as in the evaluation of coating materials and application techniques make it necessary to recommend uniform methods for measuring and testing.

Committee on Coatings Research Is Organized

A new unit committee, T-6R on Protective Coatings Research has been organized in T-6 with Robert H. Steiner, Atlas Mineral Products Co., Mertztown, Pa., as chairman. The committee will consist of one member from each of the units committees of T-6.

The function of the group is to correlate coatings research and appoint task groups to get available material and determine who will do testing.

One project contemplated is development of specific coating application information, and a decision is to be made of whether such a project is feasible.

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T-6 on Coatings has under consideration the advisability of forming a unit committee to investigate "Coatings and Linings of Water Tanks Operating Under Variable Temperatures."

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Carbon Dioxide Eyed As Corrosion Factor In Sweet Oil Wells

Some relation may exist between the extent of corrosion and the carbon dioxide content of fluids produced by sweet oil wells, studies by T-1C on Sweet Oil Well Corrosion indicate. Industry-wide studies show corrosion sometimes is independent of water production and may be severe when as little as 0.1 percent water is produced. This type of corrosion also may be independent of carbon dioxide content of the fields. These two factors distinguish the problem from the more common type of corrosion which depends on water production and carbon dioxide content.

Members of the committee believe there was a similarity between corrosion causes in these relatively water-free sweet oil wells and the causes of corrosion in gas condensate wells. It was reasoned that carbon dioxide could be the deciding corroding agent as it was in gas condensate wells, but investigation indicated this was not uniformly true because instances of damage when carbon dioxide can hardly be detected were found. Much work has been done to develop a theory which will explain corrosion in the absence of substantial volumes of either water or carbon dioxide.

Tubing from corroded wells was examined and the information thus secured was used in an effort to duplicate in the laboratory under controlled conditions instances of the same type of corrosion. The corrosion was characterized by sharp pitting. The whole of the tubing was coated with a dark red scale of honeycombed appearance. This scale proved to be acid soluble and when removed disclosed another layer of scale of white material. The second layer proved to be acid insoluble and was removed by mechanical means.

Chemical analysis of the second scale showed it to be principally calcium and barium sulfate, containing hygroscopic salts such as sodium and magnesium chloride. This scale covered the entire tubing surface, both pitted and unpitted parts. Scale in the pits conformed to the contour of the pits.

To reproduce this type of corrosion in the laboratory an airtight box was kept charged with a nitrogen atmosphere which was saturated by bubbling the nitrogen through water as it entered the box. Steel coupons were left in the box for 30 days.

The coupons were pretreated in different ways, some being coated with a composition representing the scale found on the corroded tubing and the others left blank. At the end of the test the blank coupons were substantially unchanged while severe pitting occured on the coupons which had been precoated.

While a satisfactory explanation of the reason for the scale deposits in the well has not been obtained, it was obvious it developed from produced fluids. It is believed the scale causes corrosion because of hydrolysis. Calcium and barium sulfate being sparingly soluble materials, they hydrolized in the presence of water to give a pH in the neighborhood of 4. The hydrolysis forms sulfuric acid. Because calcium sulfate is considerably more soluble than barium sulfate it may be more corrosive.

The water neceessary for this reaction is captured by the hygroscopic salts present and because only very small amounts of water are needed it may be thought of as being practically water-independent.

Only tentative conclusions have been drawn to date by the committee. More comprehensive tests are being run exploring the variables of physical and chemical composition of materials involved and exploring the relative merits of alloys, coatings and inhibitors as preventers.

Extension Is Approved For Sulfide Stress Corrosion Investigation

At least another year's continuation of the research into sulfide stress corrosion cracking has been recommended by T-1G. The research, supervised by the committee, is under direction of W. D. Robertson of Yale University. It has been under way for two years.

Fundamental factors for the sudden failure by cracking of oil well equipment subjected to high pressure gas containing hydrogen sulfide are being investigated. The committee says the work at Yale has progressed in a satisfactory manner and reports on what has been learned so far have been supplied companies who contributed to the research fund.

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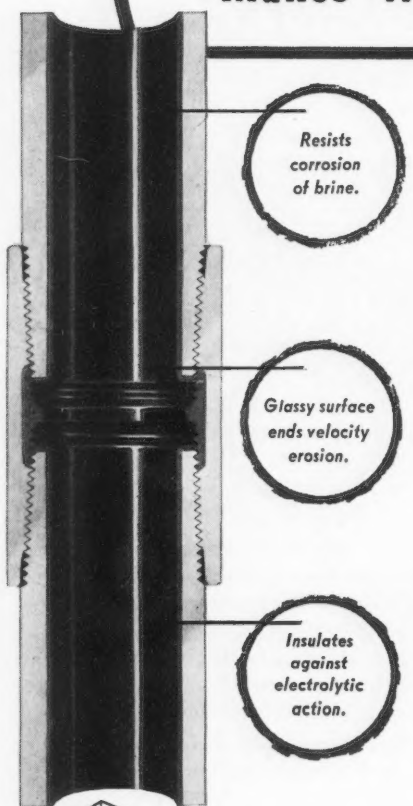

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Organics Favored as Condensate Well Inhibitors

Organic inhibitors continue to be preferred for control of corrosion in condensate wells, according to discussions among members of T-1B on Corrosion of Oil and Gas Well Equipment at the recent NACE meeting in Kansas City. R. C. Buchan, Humble Oil and Refining Co., Houston, chairman said cost of protecting wells, depending on the field and operator varies from $600 to $700 a year.

Some committee members reported three liquid inhibitors are being used experimentally with encouraging results. They are periodically dumped into the top of tubing or annulus and do not require dilution. When not diluted, however, the well must be shut in for at least 6 to 8 hours. Weekly injections are satisfactory usually, but injection every two weeks is adequate in some cases. Most operators, however, treat wells daily using diluted inhibitors.

Surveys Indicate Success

Some operators reported that tubing caliper surveys taken after two years' use of the dumping technique indicate corrosion has been stopped. In cases where isolated wells were found not to have corrosion stopped it is believed it was because shut in time was insufficient. Volume of chemical used varies from one quart per million cubic feet to one quart per three million cubic feet.

Treatment with inhibitors in stick form, reported results indicate, must be done more frequently than when liquid inhibitors are used. Current practice is to treat wells daily at first and then to treat every other day or twice weekly when iron content of effluent drops. Success with weekly injections was not uniformly reported. Further experiments are under way to improve efficiency of stick inhibitors.

Dual Completion Problems

Successful corrosion mitigation in dually completed wells can be achieved by using organic inhibitors in the annuli. It was questioned whether corrosion can be controlled by this means in dual wells when the well on the casing starts producing salt water and tends to load up and die. One triple completion was tested and found to be corrosion-free when pulled outer casing was calipered and pressure tested. It was estimated the best way to determine the amount of chemical needed was to make the determination in the individual casing, using iron content as criterion.

Two operators reported on a mechanically driven radial piston type pump for injecting inhibitors. Injection was at a one barrel per hour rate against 5000-pound pressure. Satisfactory results were reported pumping undiluted chemicals but unsatisfactory results pumping low viscosity liquids which would be the case when diluted chemicals were used. The pump could pump a hydraulic fluid into which the diluted chemical was injected.

Transportation Group Re-Named "Railroads"

The name of Unit Committee T-3E has been changed from "Transportation" to "Railroads" in recognition of the fact the committee's work so far is wholly in the railroad industry. R. A. Bardwell, Chicago & Eastern Railroad, Danville, Ill., has been named chairman and G. M. Magee, Association of American Railroads, Technology Center, Chicago, has been named vice-chairman.

Two task groups have been organized under the committee as follows:

T-3E-1 on Corrosion of Railroad Tank Cars is headed by J. R. Spraul, General American Transportation Corp., East Chicago, Ind., with C. M. Jekot, Lithcote Corp., Chicago, as vice-chairman. The group was formerly identified as TP-15A.

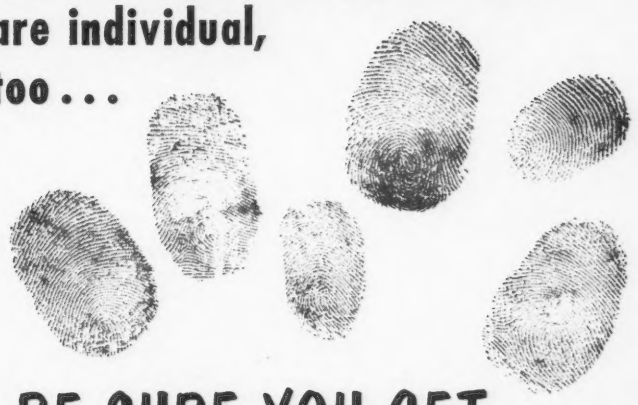
T-3E-2 on Corrosion in Railroad Hopper Cars is headed by Robert Byrne, Association of American Railroads, Chicago. The group had been identified formerly as TP-15C.

A third group to be organized under J. S. Swann, Standard Railway Equipment Co., Hammond, Ind., will be designated T-3E-3 on Corrosion Resistant Materials for Railroads.

Cast Iron Pipe Demand

A continuing high level demand for cast iron pressure pipe and fittings throughout 1954 is indicated by an analysis of trends prepared by the Business and Defense Services Administration, U. S. Dept. of Commerce. A rise in the per capita consumption of water is a reason given for the increased demand.

Water conditioning problems are individual, too . . .



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Officers Are Changed In Eleven Committees

The following officers have been named for technical committees:

T-1B on Condensate Well Corrosion. W. H. Edwards, Superior Oil Co., Houston, vice-chairman.

T-1D on Sour Oil Well Corrosion. W. C. Koger, Cities Service Oil Co., Great Bend, Kans., one of the committee's two vice-chairmen. Mr. Koger also is one of two vice-chairmen for T-1H on Oil String Casing Corrosion.

T-1F on Metallurgy in Oil and Gas Well Equipment has the following new officers: F. J. Radd, Continental Oil Co., Ponca City, Okla., chairman; F. L. Current, Oil Well Supply Co., Oil City, Pa., vice-chairman.

T-1H on Oil String Casing Corrosion. R. L. Elkins, Shell Oil Company, Midland, Texas, is one of two vice-chairmen.

T-2D on Standardization of Procedures for Measuring Pipe Coating Conductance. L. F. Heverly, Heverly Engineering Co., Kansas City, vice-chairman.

T-4A on Effects of Electrical Grounding on Corrosion. Ray M. Wainwright, University of Illinois, Urbana, chairman.

T-4B-6 on Stray Current Electrolysis. J. Svetlik, Indiana Public Service Co., Hammond, Ind.

T-4F on Materials Selection for Corrosion Mitigation in the Utility Industry. Robert R. Ashline, Dept. of Water and Power, Los Angeles, vice-chairman.

T-5A on Chemical Manufacturing Industry. R. I. Zimmerer, Westvaco Chlor-Alkali Div., Food Machinery & Chemical Corp., Charleston, W. Va., chairman. Mr. Zimmerer also is chairman of Task Group T-5A-4 on Chlorine.

T-5B on High Temperature Corrosion. John Halbig, Armco Steel Corp., Middletown, Ohio, chairman.

T-6E on Protective Coatings in Petroleum Production. J. L. Robertson, Phillips Petroleum Co., Bartlesville, Okla., chairman.

Practical Test for Water In Diesel Fuel Given

A practical, in-the-field test for water contamination in oil used in diesel engines is described in a paper presented before the international meeting of The American Society of Mechanical Engineers in Mexico City, March 10-12. The paper states when a few drops of oil are placed on an electric hotplate or other hot piece of metal, sputtering will indicate the presence of water.

The paper, "Factors Affecting Oil Drain Practices for Diesel Engines," by Lewis F. Moody, Jr., and John C. Gibb, Socony-Vacuum Oil Co., Inc., may be obtained by writing for Paper No. 54-MEX-3, ASME Order Dept., 29 W. 39th St., New York 18, N. Y. Price is 50 cents.

Finkbone Is Honored

B. P. Finkbone, Product Engineer, Research Division, Armco Steel Corp., Middletown, Ohio has been given the annual award of The Galvanizers Committee in recognition of his distinguished service to the committee and to the galvanizing industry.

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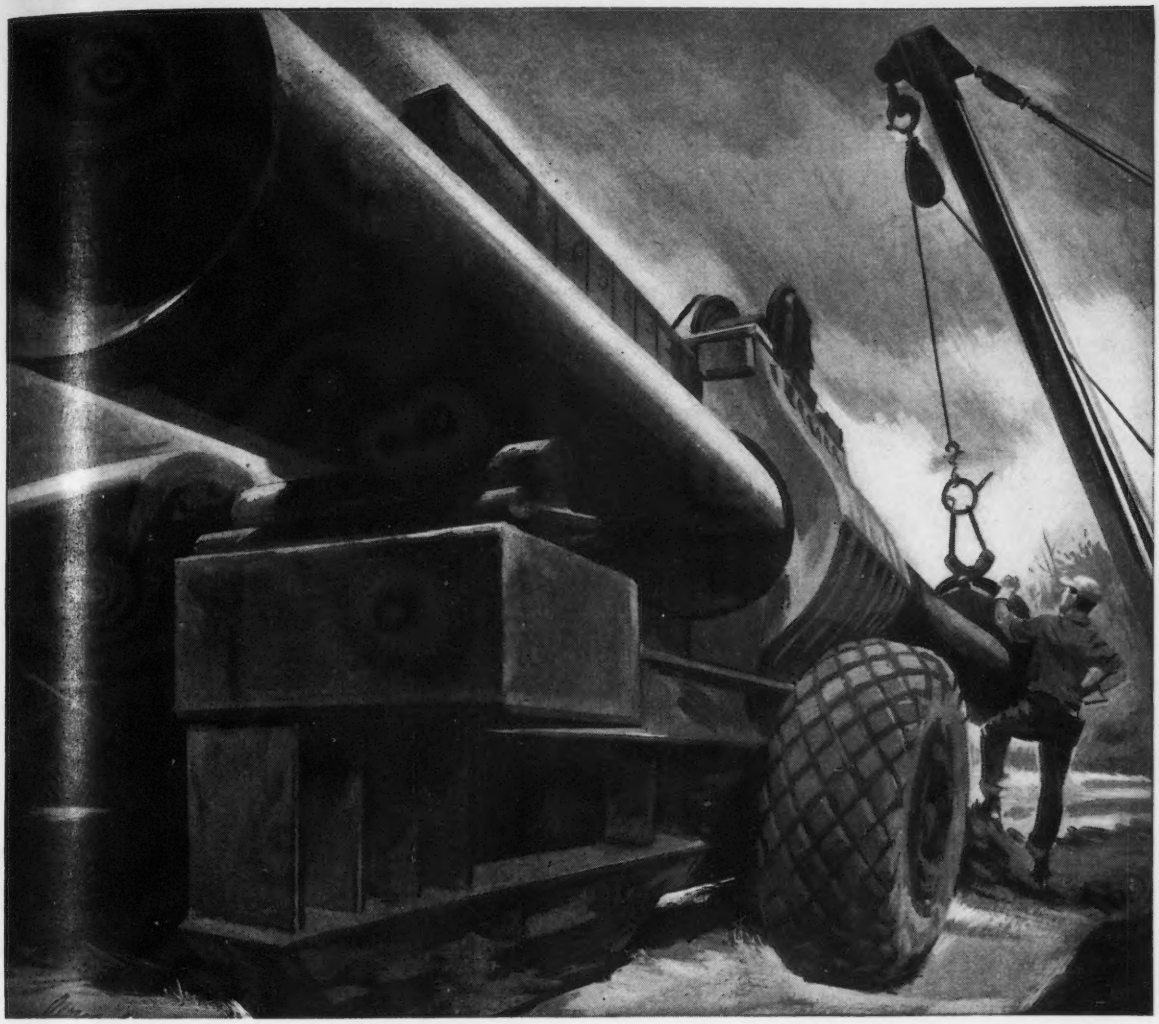

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The section of steel pipe shown above is on "a big bender" . . . the machine illustrated is putting a custom-made bend in the pipe to fit a curved section of the trench. It saves a lot of work and expense by taking care of tough angles right on the job.

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General News

Belgian Publications On Corrosion Received

D. Berman, research director of the Belgian Association for the Study, Production and Use of Materials has sent to Central Office a collection of publications of Commission 4 (Section 4) of this group devoted to protection against corrosion.

All publications are in French and approximate translations of their titles are: Studies of Paint Systems for Protection Against Atmospheric Corrosion by Pierre Van Rysselberghe and D. Bermane; Fifteen Years of Investigation of Atmospheric Corrosion in Belgium, proceedings of a report on the work of Section 4; A Study of 67 Antirust Paints, a summary of a report presented to members of Section 4 at a 1953 meeting in Brussels; Protection of Metallic Structures Against Atmospheric Corrosion, reprinted from L'Ossature Metallique, June 6, 1953; Protecting Steel Against Corrosion Through the Use of Alloying Materials, reprinted from L'Ossature Metallique, January, 1952; General Report on the Activities of Commission No. 4—1948-50.

A bibliography of publications by Section (Commission) 4 also has been issued, beginning with 1936.

Other publications sent include: Correlation of Results of Accelerated Tests and On Location Tests, Determination of the Variation of the Physical Properties of Paints as a Function of Time.

Pressure Welding Finds Use in Production

Excellent welds on copper and aluminum are secured through the use of tools similar to pliers which exert tremendous pressures on small areas. The method is now being adapted to production lines, W. A. Barnes, vice president of engineering and production, Utica Drop Forge and Tool Corp. told a meeting of tool engineers April 29. The session was one of those during the 1954 American Society of Tool Engineers' 22nd Annual Meeting held at Philadelphia. The method was developed first in England, Mr. Barnes said.

How chilling metals to 120 degrees below zero increases hardness and improves uniformity was described by R. S. Jamison, assistant to the president of Sub-Zero Products Co., Cincinnati.

Chromate conversion coatings on metals help protect them from rust and yet provide an excellent base for oil paints, C. W. Ostrander, service manager of Allied Research Products, Inc., Baltimore, reported. He recommended the coatings as a substitute for zinc coatings.

Radioactive particles introduced into underground pipe lines will assist in locating leaks and plugs, reported Lionel Goldring, Nuclear Development Associates, Inc., White Plains, N. Y.

Marburg and Gillette Lecturers Are Named

Harold F. Dodge, Quality Results Engineer and a member of the technical staff of Bell Telephone Laboratories, Inc., will present the 28th Edgar Marburg Lecture on "Interpretation of Engineering Data." The lecture will be given during during the annual meeting of the American Society for Testing Materials at Chicago June 13-18.

Richard L. Templin, Assistant Director of Research and Chief Engineer of Tests, Aluminum Company of America will present the third H. W. Gillett Memorial Lecture on "Fatigue of Aluminum." The lecture, sponsored jointly by ASTM and Battelle Memorial Institute also will be given during the annual ASTM meeting.

German Working Party On Corrosion Revived

The German Working Party on Corrosion, which held its last meeting as an international body at Frankfurt am Main in 1943 has scheduled a corrosion congress at Frankfurt on November 11 and 12, 1954. Dechema has assumed management of the vent, which will be also the annual general meeting of Dechema.

The working party will be formed of representatives from the following organizations: German Chemical Apparatus and Equipment Association, German Metallurgical Association, German Society of Gas and Water Engineers, The Society of German Chemists, The Society of Naval Architects, The Society of German Iron and Steel Makers and the Society of German Engineers.

Leonard Hill Group Has Corrosion Publication

Corrosion Technology, a new publication of the Leonard Hill Technical Group, Leonard Hill Ltd., Stratford House, 9 Eden St., London N.W. 1, is being included initially as a section in the company's monthly periodical Chemical and Process Engineering.

Vol. 1, No. 2 of the publication includes Corrosion Problems of Ammonium Sulphate Manufacture by A. W. Bamforth, The Power-Gas Corp., Ltd.; Corrosion Control for Ships and Marine Structures, a staff report on the work of the Corrosion Group of the Society of Chemical Industry; Corrosion and Design—Part 2 by L. L. Shrier, Battersea Polytechnic, London and numerous condensations and digests of other material on corrosion mitigation.

New British Magazine On Corrosion Started

"Corrosion Prevention and Control," a periodical published at 140 Cromwell Road, London, S.W. 7, which is said not to be affiliated with any British technical organization is now available to subscribers in the United States. Copies of the March, 1954 issue, Vol. 1, No. 1 were made available at the recent NACE Tenth Annual Conference and Exhibition at Kansas City.

Contents of the first issue include articles on cathodic protection, zirconium, paints, plastics and numerous news reports of corrosion activities, including the meetings of technical organizations in Great Britain. The book measures 6 x 9 inches and contains 64 pages, in addition to the cover. An editorial program outlined indicates the magazine intends to cover theory and mechanism, corrosive environments, testing, prevention and materials.

Near East Engineering Schools Are Listed

Engineering schools in the Near East number at least eight, according to reliable information recently supplied. A statement published in the February, 1954 issue of CORROSION that the Haifa Technion was the only engineering school in the Near East was in error.

Engineering schools include: American University of Beirut and French University of Beirut, Lebanon; College of Engineering of the Syrian University in Aleppo, Syria; University of Cairo, University of Alexandria and University of Aswan, Egypt; Royal College of Engineers, Baghdad, Iraq and Robert's College in Istanbul, Turkey.

Proved Reserves of Oil And Gas Increase Again

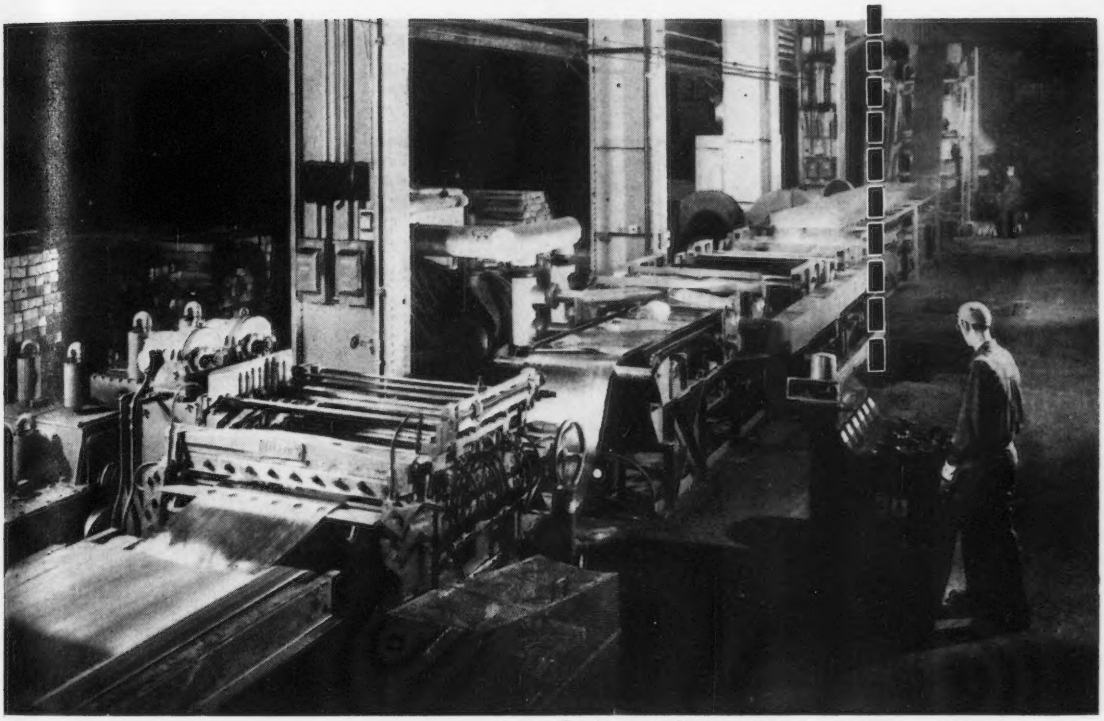
According to the American Petroleum Institute, proved reserves of liquid petroleum and natural gas rose to new all-time peaks in 1953 despite the highest production rates in history. Proved reserves of liquid petroleum now total 34.3 billion barrels and those of natural gas 211.4 trillion cubic feet. Additions to proved reserves were accomplished in the face of record-breaking withdrawals of oil and gas in 1953.

Havey Is Reelected

Marshall L. Havey has been reelected president of the American Zinc Institute. Mr. Havey is assistant to the president of the New Jersey Zinc Company, New York City.

A signal achievement in sheet steel metallurgy

the continuous galvanizing process



Continuous galvanizing line
Courtesy: *Wean Engineering Company*

THE greatest advent in the sheet galvanizing industry since its inception is the continuous strip galvanizing line. Although zinc has been used as a protective coating for iron and steel products for more than a century, this change in method of application has established new standards of corrosion resistance, workability and surface quality for galvanized sheet steel.

Today's continuous galvanizing process imparts greater ductility to the steel base and results in a lighter, more uniform coating which takes the toughest forming without cracking, flaking, or peeling of the zinc coating.

Zinc is used as a protective coating more than any other metal. In fact, galvanizing accounts for the metal's largest use. It is easy to apply, low in cost, is readily available and lends itself especially well to continuous processing. Furthermore, zinc gives double protection. In addition to providing a mechanical barrier of corrosion-resistant metal, zinc protects steel by galvanic action. As a result, rusting of the steel at cut ends—or at bare spots caused by mechanical injury to the coating—is avoided as long as enough zinc remains nearby to be preferentially attacked.

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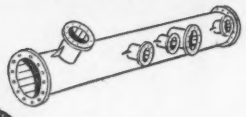

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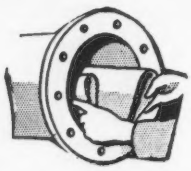

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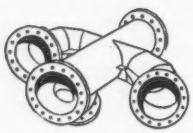

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Inter Society Corrosion Committee

CORROSION MEETINGS
CALENDAR

June

12-25 American Institute of Electrical Engineers, General Summer Meeting, Biltmore Hotel, Los Angeles, Calif.

13-18 American Society for Testing Materials, Annual Meeting and Exhibit, Sherman Hotel, Chicago, Ill.

20-24 Canadian Gas Association, Banff Springs Hotel, Banff, Alberta, Canada.

20-24 American Society of Mechanical Engineers, Hotel William Penn, Pittsburgh, Pennsylvania.

20-25 American Institute of Chemical Engineers (National Meeting), University of Michigan, Ann Arbor, Michigan.

28-29 Michigan Gas Association, The Grand Hotel, Mackinac Island, Michigan.

28-30 American Society of Heating and Ventilating Engineers (Semi-Annual Meeting), New Ocean House, Swampscott, Mass.

(No Date) National District Heating Association, Annual Meeting.

July

11-14 American Society of Refrigerating Engineers, Hotel Olympic, Seattle, Washington.

Sept.

1-16 International Electrotechnical Commission, Golden Jubilee Meeting, University of Pennsylvania, Philadelphia, Pa.

8-10 Pacific Coast Gas Association, Victoria, British Columbia.

12-16 American Institute of Chemical Engineers (National Meeting) Hotel Colorado, Glenwood Springs, Colo.

28-29 Texas Mid-Continent Oil and Gas Association, Baker Hotel, Dallas, Texas.

Sept. 29-Oct. 1 Porcelain Enamel Institute, Annual Meeting, The Greenbriar, White Sulphur Springs, West Virginia.

Oct.

3-7 The Electrochemical Society, Fall Meeting, Boston, Mass.

11-14 American Gas Association, Annual Convention, Atlantic City, New Jersey.

11-15 American Institute of Electrical Engineers, General Fall Meeting, Hotel Morrison, Chicago, Ill.

12-15 National Association of Corrosion Engineers, South Central Regional Meeting, Dallas, Texas.

17-23 American Society for Metals (National Metal Congress and National Metal Exposition), Hotel Statler, Cleveland, Ohio.

28-29 American Society of Mechanical Engineers (Fuels-AIME Coal Conference), Hotel William Penn, Pittsburgh, Pennsylvania.

Nov.

1-3 American Institute of Mining and Metallurgical Engineers, Institute of Metals Division, Fall Meeting, Sheraton Hotel, Chicago, Ill.

1-5 National Metal Exposition, Chicago, Ill.

8-11 American Petroleum Institute, Conrad Hilton Hotel, Chicago, Ill.

15-18 American Gas Association, Operating Section, Organization Meetings, Hotel New Yorker, New York.

28-Dec. 1 American Society of Refrigerating Engineers (50th Annual Meeting), Hotel Ben Franklin, Philadelphia, Pennsylvania.

28-Dec. 3 American Society of Mechanical Engineers (Annual Meeting), Hotel Statler, New York, New York.

Dec.

12-15 American Institute of Chemical Engineers (Annual Meeting), Statler Hotel, New York, New York

1955

Feb.

16-18 National Association of Corrosion Engineers (Sixth Annual Pipeliners Short Course) Mayo Hotel, Tulsa, Oklahoma.

May

1-14 American Institute of Chemical Engineers, Shamrock Hotel, Houston, Texas.

9-13 A.G.A. Industrial Gas School—(location to be announced).

16-18 Southern Gas Association, New Orleans, Louisiana.

June

5-9 Canadian Gas Association, Annual Meeting, General Brock Hotel, Niagara Falls, Ontario, Canada.

13-18 American Society of Mechanical Engineers (75th Anniversary Meeting), Congress and Hilton Hotels, Chicago, Illinois.

Oct.

17-19 A.G.A. Annual Convention, Los Angeles, California

17-21 National Metal Exposition, Detroit, Michigan (A.G.A. will exhibit).

Nov.

13-18 The American Society of Mechanical Engineers, Congress & Hilton Hotels, Chicago, Illinois.

27-30 American Institute of Chemical Engineers (Annual Meeting), Statler Hotel, Detroit, Michigan.

1956

Oct.

15-16 National Metal Exposition, Philadelphia, Pa. (A.G.A. will exhibit).

29 to Nov. 1 A.G.A. Annual Convention, Atlantic City, New Jersey.

Nov.

25-30 The American Society of Mechanical Engineers, Statler Hotel, New York, New York.

1957

Oct.

21-25 National Metal Exposition, Cleveland, Ohio (A.G.A. will exhibit).

PUBLICATIONS ON CORROSION

Remittances must accompany all orders for literature the aggregate cost of which is less than $5. Orders of value greater than $5 will be invoiced if requested.

● BOOKS

Joint Symposium on Cathodic Protection

Postpaid to members ECS and NACE, per copy ..... $ 6.00
To all others, per copy 8.00

Bibliographic Survey of Corrosion, 1945

Postpaid to NACE members, per copy ..... $ 4.00
To others, not NACE members, per copy 5.00

Bibliographic Survey of Corrosion, 1946-47

Postpaid to NACE members, per copy ..... $ 7.00
To others, not NACE members, per copy 9.00

1945 and 1946-47 Bibliographies Combined

Postpaid to NACE members ... $ 9.00
To others, not NACE members .. 12.00

● BOOKLETS

Control of Pipe Line Corrosion by O. C. Mudd

Per Copy, postpaid ..... $ 1.25
(5 or more copies to one address, per copy, $1)

Report of the Correlating Committee on Cathodic Protection

1 to 10 copies, each 50c
11 to 100 copies, each 35c
More than 100 copies, each 25c
Postpaid

Symposium on Sulfide Stress Corrosion

Publication 52-3
Per Copy, postpaid ..... $ 1.00
(5 or more copies to one address, per copy, 50c)

NACE Committee Directory

Publication 53-2
Per Copy, postpaid, members ... $ 1.00
(Non-members of NACE, $2)

● TECHNICAL REPORTS

TP-1 Report on Field Testing of 32 Alloys in the Flow Streams of Seven Condensate Wells (Pub. 50-3) NACE members, $8; Non-members, $10 per copy.

TP-2 First Interim Report on Galvanic Anode Tests. (Pub. 50-2) NACE members, $3; Non-members, $5 per copy.

TP-3 First Interim Report on Ground Anode Tests. (Pub. 50-1) NACE members, $3; Non-members, $5 per copy.

TP-1D Sour Oil Well Corrosion. *Corrosion* August, 1952 issue. NACE members, $.50; Non-members $1 per copy.

TP-1G Field Experience With Cracking of High Strength Steel in Sour Gas and Oil Wells. (Included in Symposium on Sulfide Stress Corrosion. (Pub. 52-3) $1 per copy. 5 or more copies to one address, $.50 per copy.

TP-5A Materials of Construction for Handling Sulfuric Acid. *Corrosion*, August, 1951, issue. NACE members, $.50; Non-members, $1 per copy.

TP-5C Stress Corrosion Cracking in Alkaline Solutions. (Pub. 51-3) Per copy, $.50.

TP-6G First Interim Report on Recommended Practices for Surface Preparation of Steel. (Pub. 50-5) Per copy, $.50.

TP-6G Second Interim Report on Surface Preparation of Steels for Organic and Other Coatings. (Pub. 53-1) Per copy, $1; five or more copies to one address, per copy $.50.

TP-12 Report on Electrical Grounding Practices. Per copy $.50.

TP-19 Corrosive Effects of Deicing Salts—A Progress Report by Technical Practices Committee 19. *Corrosion*, January, 1954, issue. NACE members $.50; Non-members $1 per copy.

● REPRINTS

Cathodic Protection and Pipe Lines

Mitigation of Corrosion on City Gas Distribution Systems by A. D. Simpson, Jr. .50

Paints and Coatings

Gasoline Resistant Tank Coatings by W. W. Cranmer ..... .50

Tests, Properties of Corrosion Preventive Lubricants for Lead Sheathed Cables in Underground Ducts—A Discussion by Howard S. Phelps and Frank Kahn ... .50

Petroleum Production and Storage

Corrosion in Condensate and in High Pressure Sweet Oil Wells by R. C. Buchan .. .50

Miscellaneous

Resistance of Aluminum Alloys to Weathering by C. J. Walton, D. O. Sprowls and J. A. Nock, Jr., and Resistance of Aluminum Alloys to Contaminated Atmospheres by W. W. Binger, R. H. Wagner and R. H. Brown ..... .50

Causes of Corrosion in Airplanes and Methods of Prevention by N. H. Simpson .... .50

Salt Spray Testing Bibliography by Lorraine Voight ..... .50

The Cost of Corrosion to the United States by H. H. Uhlig ..... .50

Why Metals Corrode by H. H. Uhlig ..... .50

Corrosion Control by Magic—It's Wonderful by H. H. Uhlig ..... .50

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Symposium on Internal Corrosion of Tankers. Part 3—Corrosion Control in Practice by A. B. Kurz ..... .50

Index to Corrosion, Volume 8 ..... .50

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Copies of all issues are available except:

1947—January, March, June, July, August, September, November, December.

1948—January, February, May, June, July, August, December.

1949—January, February, March, June, July, August, September, October.

1950—January, February, April, May.

1951—January, February, March, October.

1952—March, April.

1954—January.

Indices to Corrosion technical literature have been published as follows:

5-Year Index, 1945-49 inclusive and
Index to Vol. 6, 1950 ..... December, 1950
Index to Vol. 7 ..... December, 1951
Index to Vol. 8 ..... December, 1952
Index to Vol. 9 ..... December, 1953

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NATIONAL ASSOCIATION of CORROSION ENGINEERS

HOUSTON **1061 M & M Building** **TEXAS**

Corrosion Coupons Used to Check Vent Gas Effects

External Corrosion Is Reduced When Dust and Corrosive Gas Captured

Dust, corrosive gases and disagreeable odors were found to be the contribution to air pollution of Mathieson Chemical Corporation's fertilizer plant on the Houston Ship Channel, it was reported by S. Cottrell, vice-president and director of operations of the company's Agricultural Chemical Division before a meeting April 23 of the 1954 Southern Industrial Wastes Conference. This was the decision reached when the company evaluated its pollution problem on a logical basis.

The dust problem was solved by bag type dust filters. Dust so recovered quickly paid for the installations. The external corrosion of buildings was substantially reduced also when the dust was removed from the air. Savings from this effect were not calculated.

Fluorine gas is treated in wet scrubbers. Tests on scrubbing efficiency are made by exposing a piece of window glass a portion of which is covered by adhesive tape. If much fluorine is being lost a few days' exposure will be indicated by the difference in appearnace between the covered and uncovered portions of the glass.

Concentrations of sulfur dioxide in the 40,000 cfm exit gases of the acid plant stacks caused complaints in nearby residential areas even though the ground concentration at the plant was negligible. So the fumes are now scrubbed in a two-stage ammonia scrubber, converting the sulfur in the exit gases to ammonium sulfate.

Odors from the organic content of spent alkylation acid from nearby petroleum refineries, used in the plant's processes, are expected to be removed when the company puts into operation a large incinerator in which the gases will be heated to 1500 degrees F.

Mr. Cottrell recommends the following procedure for a chemical plant with respect to air pollution:

1. Find out what your plant is putting into the air.
2. Find a commercially possible way of reducing the pollution.
3. Do something about it.

Mr. Cottrell also recommended companies take steps to keep the public informed about their work in reducing air pollution.

$2,200,000 Spent Yearly On Pollution Research

Roy F. Weston, sanitary engineer, Atlantic Refining Co., reported in a talk before the annual meeting of the American Institute of Chemical Engineers that more than $2,200,000 is being spent annually in the United States for research into means of reducing industrial pollution.

He said industry has about $1 billion invested in waste treatment plants and was of the opinion the industrial waste load exceeded that of the municipal sewage sanitary load.

Cyclone Scrubber Cuts Varnish Fumes

Irritating fumes, the drop-outs from which spotted the finish of cars parked near exhaust stacks posed a serious problem for DuPont de Nemours & Company's varnish plant supplying varnish to the automobile industry. C. R. DeBow, supervisor of the fabrics and finished department told an April 21 session of the 1954 Southern Industrial Wastes Conference at Houston how the problem was solved.

The company began boiling the varnish in a closed stainless steel agitated kettle the fumes from which were run through a cyclone scrubber. The change reduced the fumes to negligible proportions and saved 50 gallons of oil per batch of material which formerly had been lost in the exhaust.

Continuous Attention to Waste Disposal Called Necessary by Morris

Continuous attention to waste disposal problems, systematic inspection of sources of accidental contamination, research into the toxicity of various chemical wastes and a policy that "no process is complete unless it can be operated without pollution of air or water," characterize the waste disposal activities of Monsanto Chemical Company's plants at Texas City. H. E. Morris, director of research, Texas Division, Monsanto Chemical Company developed these themes in his paper "An Integrated Plant for the Control of Air and Water Pollution," before the April 23 session of the 1954 Southern Industrial Wastes Conference at Houston.

Monsanto's operation at Texas City, involving production of ethylene, styrene, acrylonitrile and vinyl chloride poses numerous problems in disposing of aqueous and gaseous wastes. Among the successful solutions reported by Mr. Morris was the development of a method of burning soot produced as a by-product of acetylene gas manufacture from natural gas. The soot slurry is burned and there is no smoke or contamination either air or water borne as a result.

In operation at the plant is a special instrument capable of detecting minute traces of HCN in air. It monitors air drawn from several locations and rings an alarm if the HCN content exceeds 40 ppm.

Numerous other ingenious solutions of contamination problems were related by Mr. Morris, designed to remove from liquid effluent such substances as HCN, acrylonitrile wastes, copper, mercury salts and high boiling tars.

When substantial quantities of chlorinated tars must be processed, they are burned when wind direction will carry the plume out over the bay. Nearly $1,000,000 has been spent for pollution control and monthly expense is about $25,000, Mr. Morris reported.

Dow Uses Weight Loss Data to Plot Corrosive Areas

Corrosion coupons are used to locate sources of mildly corrosive vent gases and to evaluate their effect on nearby plant areas at the Freeport, Texas plant of The Dow Chemical Company. C. M. Shigley, director of technical research, described at a meeting of the 1954 Southern Industrial Wastes Conference at Houston April 21 the method used at this plant.

It consists of exposing weighed bare steel coupons vertically mounted on wooden posts throughout the plant. After about four months during which wind velocity and direction are charted, the coupons are collected, cleaned and weighed. By plotting contours through points of equal corrosion loss on a map related to the location of the coupons it is possible by correlating the results with the wind studies to locate points where corrosives were being emitted into the air.

This system is in continuous use to rate the effectiveness of control measures, Mr. Shigley said.

Mr. Shigley's address "Pollution Control at the Source" also pointed out that industries must now consider, in deciding the location of a plant, in addition to other traditional considerations, the kind, quantity and nature of pollutants emitted by adjacent plants and whether prevailing winds, currents or tide effects will have some bearing on waste disposal.

Black Urges Planning Ahead to Anticipate Enviromental Changes

Highlights of the opening address by Dr. A. P. Black, University of Florida, at the 1954 Southern Industrial Wastes Conference at Houston April 21-23 are:

The public must plan ahead for changing environment. Fundamental balances formerly existing have been affected by indoor plumbing and wet process operations.

Because 80 percent of the population of the United States has been released from the necessity of producing food, the employment of this 80 percent in industrial and service activities will drastically affect the environment.

The principal recent change in human environment has been the development of so-called synthetic materials.

Water pollution consists of sanitary waste, industrial waste and the wastes contained in run-off.

World temperatures are increasing, perhaps in part as a result of the carbon dioxide from burning fuels.

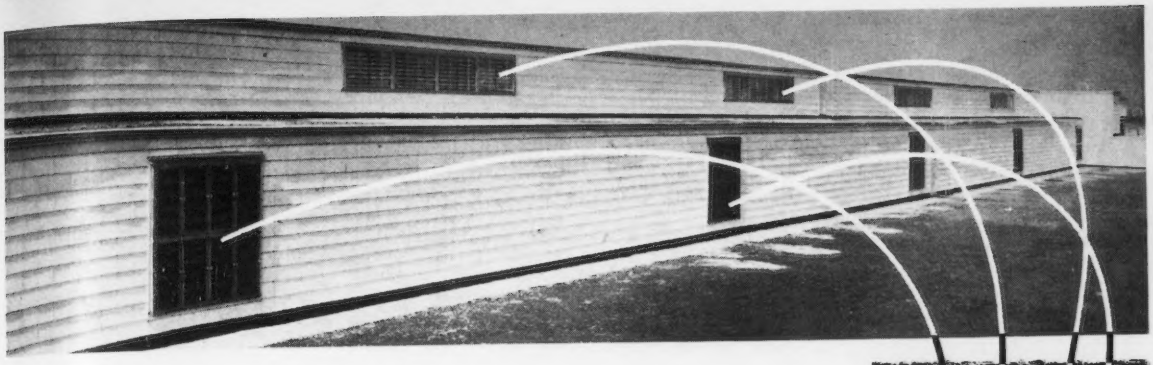
More cooling towers should be used.

Overdesign wastes water.

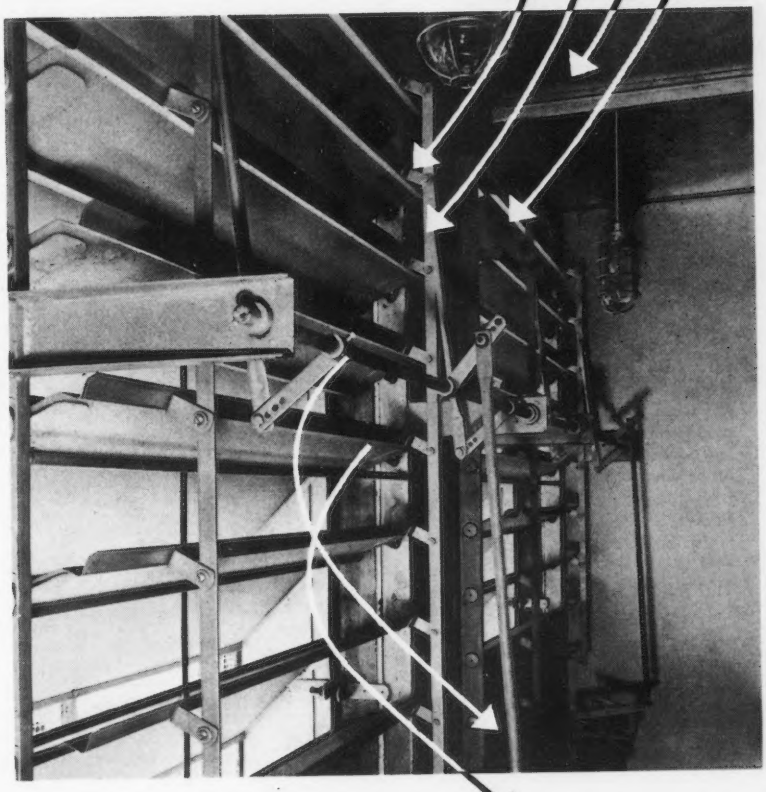
Water problems are regional, not national.

Water pollution commissions for interstate cooperation are needed in the South.

Recovery of useful products from effluent water should be encouraged and speeded.



Corrosion is out the window HERE



Photos show air conditioning apparatus house, and fresh air louvre units manufactured by The Bahnson Company, Winston-Salem, N. C. Coatings were formulated by **Specialty Coatings, Inc., Division of Thompson & Co.**, Oakmont, Pa.

The steel framework, fixed louvres, and dampers of this textile-mill air conditioning installation are thoroughly protected with coatings based on BAKELITE Vinyl Resins.

The whole unit is exposed to the outside—to potentially corrosive industrial atmosphere, high humidity, and changeable weather and temperatures. Protection is a must.

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Vast Strides in Pollution Control of Air, Water Resources Cited at Houston Meeting

Preoperational Survey Of Air Urged Before Plant Is Established

A survey of air pollution should be made in an area before a decision is made to locate the plant there. James M. Gill, Superintendent Ethyl Chloride Operations, Dow Chemical Company, speaking before the 1954 Southern Industrial Wastes Conference April 21 at Houston urged that companies determine what pollutants are present already in the air near their proposed plants.

It is important to know if another plant produces a similar potential contaminant in the area because it will prove difficult to assess blame for future contamination when both plants emit the same vapors. Further, he urged that wind and weather data be examined, air pollution complaints be investigated, other industries consulted and the extent of existing damage from air pollution in a 5 to 10-mile radius be determined. Color photographs should be taken for future reference.

An aerial reconnaisance, including the taking of color photographs was urged also because these surveys and photographs frequently reveal facts invisible from the ground level.

An air pollution survey should consider the more subtle factors involved in multiple pollution effects and photosynthesis. He pointed to the situation in Los Angeles as an indication of how futile half measures are in controlling air pollution.

Tracer Technique for Air Pollution Survey Called Useful Tool

How to use fluorescent powders as tracers in determining the volume and extent of distribution of air contaminants was described by Ernest J. Steker, Chief, Aerometry Development, The Ralph M. Parsons Co., Pasadena, Cal. on the afternoon of April 21 at Houston. He addressed a session of the 1954 Southern Industrial Wastes Conference held at the Shamrock Hotel. Mr. Steker described how grains of fluorescent powder, released into the air can be captured and counted to determine the distribution and concentration of pollutants.

It is possible also to make studies which show the distribution of the particles in a cubic volume about the vicinity to be studied, he said.

The end product of a survey made by this method is an iso-contamination map. Because the volume of fluorescent material is known it is possible to compute the probable volume of fall of contaminants from the source of waste or dust. Mr. Steker said the method puts a tool in the hands of plant management receiving complaints of air pollution damage or threatened with damage suits which makes it possible to determine to what extent, if any, the plant is responsible for the complaints or claimed damage.

Vast strides have been made in recent years in the control of pollution by industry of the nation's water and air resources. Results of industry's efforts already are evident and it seems likely that current investigations will develop satisfactory solutions to many of the nation's as yet unsolved pollution problems.

These facts were underlined by speakers at the 1954 Southern Industrial Wastes Conference held at Houston April 21-23. The conference, sponsored by the Southern Association of Science and Industry, Inc., Texas Chemical Council and the Manufacturing Chemists' Association, Inc., was held at the Shamrock Hotel with about 300 representatives of industry and government present.

The talks covered evaluations of the pollution problem with respect to its total effect and in relation to the magnitude of the resources affected and discussions of tests, techniques and pollution control measures for both water and air borne wastes.

Of especial interest to corrosion workers were descriptions of methods of rating the relative corrosivity in different areas of a chemical plant, methods for surveying the distribution of air contaminants emitted by stacks and descriptions of methods of disposing of chemical plant effluent after treatment by biological methods.

Awards were made by the Southern Association of Science and Industry, Inc. for distinguished service to the South during 1954 at a banquet held Thursday, April 22. William E. Mitchell, president of the Atlantic Realty Co., Atlanta; Dr. Abel Wolman, Johns Hopkins University, Baltimore and John Temple Graves, Birmingham Post-Herald were the honorees.

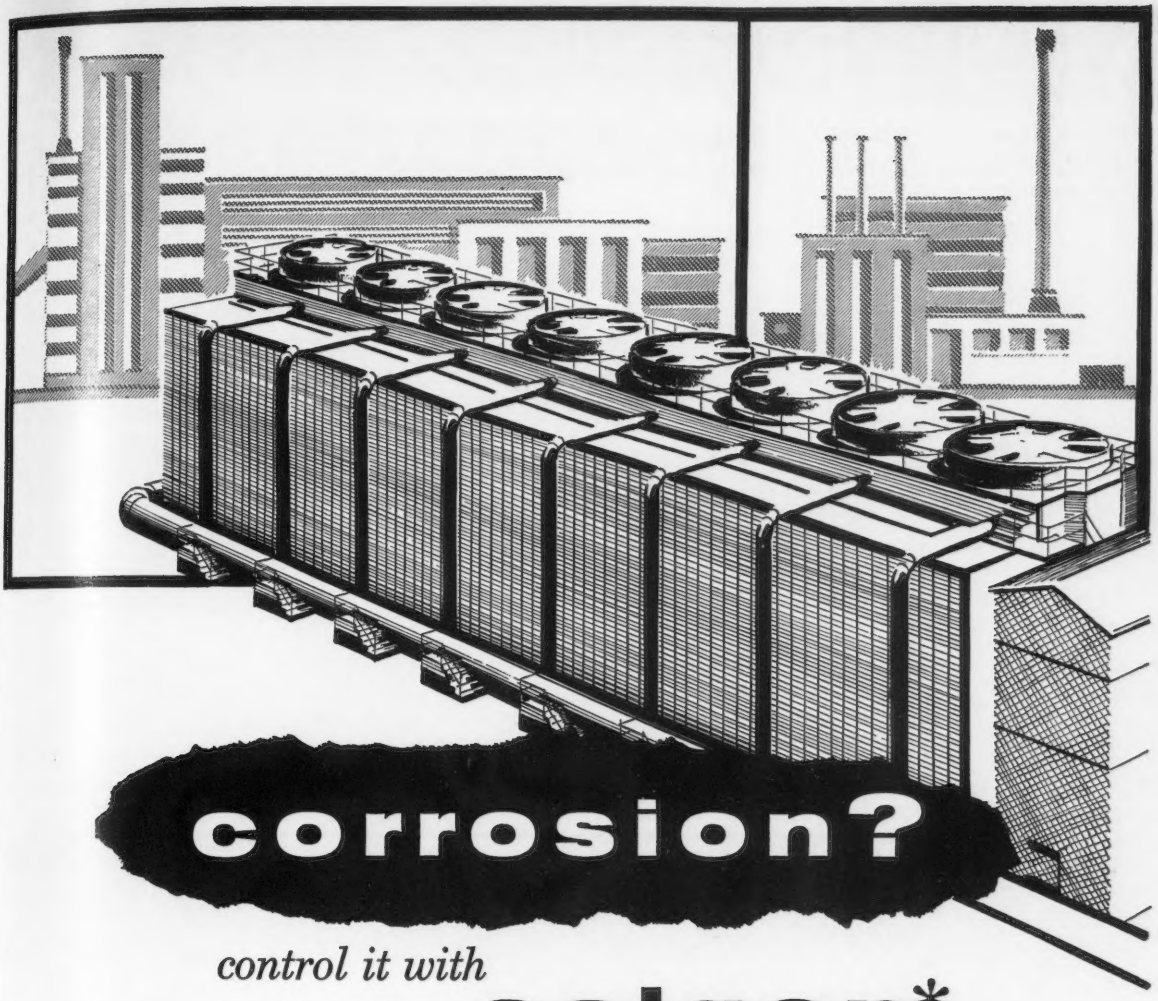
Deciduous Trees Absorb Sulfur From Flue Dust

Sulfur dioxide in flue dust from a power plant burning coal is absorbed by deciduous trees and will damage or kill them if the concentration is great enough. F. W. Thomas, Chief, Air Pollution Studies Section, Division of Health and Safety, Tennessee Valley Authority told the 1954 Southern Industrial Wastes Council at Houston April 21. Conifers apparently do not absorb the material, he said.

Mr. Thomas' talk concerned efforts by the TVA to analyze plume patterns from plant stacks in an effort to see if the pattern could be correlated with ground studies of ash fall.

Lead peroxide is used in the evaluation program. Pickle jars containing 100 sq. cm. of gauze impregnated with lead peroxide are exposed in the area under study. After a period of exposeure the amount of lead sulfate is measured to determine extent of fall. Isoplots can be constructed with data from these jars, he said.

TVA is investigating the possibility of recovering salable sulfur dioxide and other by-products from flue gases. No answers are available yet, he said.



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†Calgon is the Registered Trademark of Calgon, Inc. for its sodium phosphate glass (sodium hexametaphosphate) products.

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Industry's Contribution To Air Pollution Given By ASME Executive

Contributions of the iron and steel and other industries to air pollution are included among data given by Frederick S. Mallette, executive secretary of the Committee on Air Pollution Controls of the American Society of Mechanical engineers as follows:

Beehive coke ovens are a notable contributor to air pollution.

Waste gases from a 65-ton open hearth furnace have been estimated at 124,000 cubic feet per ton. A mill of 1,000,000-ton capacity may discharge between 500 and 1000 pounds of sulfur dioxide per hour.

The electrostatic precipitator is the most effective, though expensive, solution of air pollution control.

A 25-ton Bessemer converter may emit 2,000,000 cubic feet of waste gases as hot as the charge. Only 33 converters remain in use.

In the chemical industry a high pressure water fog system successfully prevents air pollution from air-blown sulfuric acid concentrators.

Catalytic oxidation seems to be the best answer to the odor problems of synthetic and reclaim rubber processors and those resulting from the cooking of resins and varnishes.

A major part of the air pollution problem of Los Angeles county is believed to be due to the exhaust gases from the 2,000,000 automobiles in the district which burn more than 4,000,000 gallons of gasoline daily. The Los Angeles Air Pollution District has a $500,000 annual budget and employs 100.

A small amount of sulfuric acid mist, combined with sulfur dioxide is capable of producing a severe respiratory effect.

References on Waste Disposal Being Collected

Ten thousand references on waste disposal problems and solutions are being collected by the National Technical Task Committee on Industrial Wastes. These references, which are being published on punched cards and coded, probably will be sold on a cost basis ultimately. Louis F. Warrick, Senior Sanitary Engineer, Public Health Service, Department of Health, Education and Welfare, United States Government, Washington, told members of the 1954 Southern Industrial Wastes Conference April 22 at Houston that 405 research projects are underway now into waste problems at a cost of about $3,000,000.

The task committee publishes a news quarterly and has prepared a number of guides for industrial waste disposal including those for by-products coke plants, refineries, milk processing plants and others.

Air Analysis by Catalyst

"A New Catalyst for Atmospheric Analysis and Control," by R. J. Ruff, Catalytic Combustion Corp., is among the papers to be presented at the 57th Annual Meeting of the American Society for Testing Materials at Chicago, June 13-18.

Five Air Contamination Papers Are Scheduled

Five discussions related to air contamination are among those listed in the program of the Symposium on Instrumentation for Industrial Hygiene at the University of Michigan May 24-27. The discussions are:

Instruments for Sampling and Analyzing Organic Vapors in Air by E. M. Adams, Assistant Director Biochemical Research Dept., The Dow Chemical Company, Midland, Mich.

Developments in the Sampling of Air-Borne Dust by Theodore F. Hatch, University of Pittsburgh.

Calibration of Gas, Vapor and Dust Instruments—Their Accuracy and Sensitivity by E. W. Gilliland, Chief Chemist, Mine Safety Appliances Co., Pittsburgh.

Meteorological Measurements in Air Pollution Studies by E. W. Hewson, Dept. of Civil Engineering, University of Michigan.

Filter Collecting Media by Leslie A. Chambers, Director of Research, Environmental Health Center, U. S. Public Health Service, Cincinnati.

•

Nineteen papers presented will appear in the Proceedings of the 1954 Southern Industrial Wastes Conference held April 21-23 at the Shamrock Hotel, Houston. Copies may be obtained by writing to Public Relations Dept., Manufacturing Chemists Association, 1625 Eye Street N.W., Washington 6, D. C. The proceedings will cost $2.50 each and orders must be received before June 1. Publication in early summer is planned.

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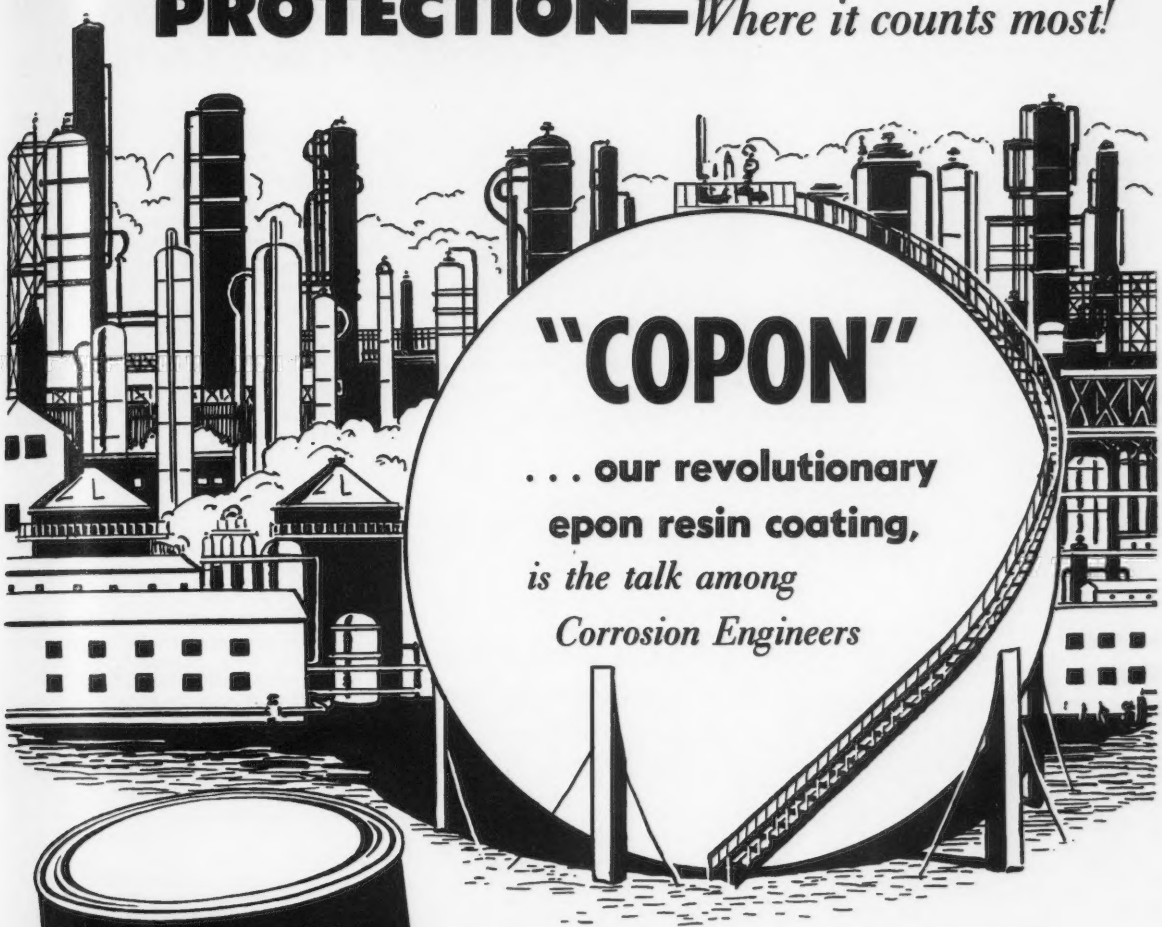

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Three Corrosion Papers Given at API Session

Three corrosion papers were presented at the May 10 session on corrosion during the American Petroleum Institute Division of Refining meeting at Houston. The Nineteenth Mid-Year Meeting was held May 10-13 at the Rice Hotel.

Numerous questions from the floor from an audience that overflowed the meeting room into an adjacent room indicated a high degree of interest. Questions were directed principally toward securing specific application and operation recommendations.

A May 12 meeting was held on the waste disposal with six items on the program, including a report on the Research Program of the Smoke and Fumes Committee by Vance N. Jenkins, Union Oil Co. of California, Los Angeles, executive secretary of the committee. The waste disposal papers included: New Oil-Reclamation and Waste Disposal Facilities by W. L. Pursell and T. W. Ferguson, Skelly Oil Co., El Dorado, Kans.; Preferential Withdrawal of Catalyst Fines to Reduce FCC Stack Losses by C. A. Seibert, Jr. and D. L. Cleveland, Shell Oil Co., Wilmington, Cal.; New Developments in the Disposal of Refinery Waste Gases by D. B. Ardern, Houdry Process Corp., Philadelphia, and Raymond C. Lassiat, Sun Oil Co., Philadelphia; The Chemical Flocculation of a Refinery Effluent by Roy F. Weston and R. G. Merman, The Atlantic Refining Co., Philadelphia and Planning and Execution of a Refinery Waste Stream Survey by A. P. Debbis, Jr., Esso Standard Oil Co., Linden, N. J.

G. J. Samuelson, Petrolite Corp., St. Louis, Mo., addressing American Petroleum Institute corrosion session at Houston May 10.

Salt Removal Cited as Vital Step in Reducing Hydrogen Chloride Damage

Removal of salt from crudes before refining to reduce the amount of hydrogen chloride evolved may be a means of reducing corrosion from this source, G. J. Samuelson, Petrolite Corp., St. Louis, Mo. told members present for an API corrosion session at Houston May 10. Mr. Samuelson gave details of laboratory tests designed to simulate refinery conditions in which the effect of de-salting was evaluated. His paper "Hydrogen-Chloride Evolution from Crude Oils as a Function of Salt Concentration," indicated that salt content in excess of 10 ptb can have serious consequences.

His work consisted of testing samples of crudes desalted and not desalted and measuring the evolution of hydrogen chloride from each.

Prevention of Corrosion In Heat Exchangers Is Continuing Job

Corrosion prevention in heat exchangers begins with design, continues through construction phases and must be continuously applied if satisfactory service is to be achieved. This was the general tenor of the remarks of J. D. Munro, Standard Oil Development Co., Linden, N. J. before the corrosion session at the Refinery Division, American Petroleum Institute meeting at Houston May 10. Mr. Munro opened his remarks by pointing out the various kinds

(Continued on Page 27)

7-Year Life Now Rule vs 2.5 Years Expected in 1948

A reduction in the ratio of paint material cost to labor to 1 to 1 in four years has been achieved by Shell Oil Company. This was accomplished as a result in part of the establishment of a management committee on corrosion, whose subcommittee on atmospheric corrosion has developed the time-saving methods now in use. This information was included in the paper "Selection of Paints and Application in Combating Atmospheric Corrosion" by F. T. Radecke, Shell Oil Co., Wood River, Ill. chairman of the company's atmospheric corrosion subcommittee. Cost of materials vs paint in 1948 was on a 4 to 1 ratio, Mr. Radecke said. Thickness has increased from 5.5 to 6 mils in 4 years and minimum service life of 7 years is now anticipated compared to life of 2-5 years in 1948.

Practices of his company were explained by Mr. Radecke as follows:

1. All paints are bought by a centralized purchasing department from manufacturers who compound the paints according to Shell's formulations.

2. Paint craft supervisors are the key to a successful painting program.

3. Epons and vinyls in experience data collected so far seem to be parallel in performance.

4. Specification paints have proved to cost about the same as private brand paints.

5. Class 2 sandblasting is preferred when safety factors permit.

6. Scrapers are supplemented by heavy grit pads which improve surface preparation measurably.

7. Some painting is done by pressure feed roller and by brush when there is no option.

8. Paint pumps are extremely useful.

9. Painters must get careful instruction in spray technique.

10. Added thickness for rough places is necessary.

11. New steel is allowed to weather so scale is removed before painting.

12. Phosphoric acid spray is used as a surface preparation method. Vinyl-type must be used on sandblasted surface and water soluble type is effective for cleaning off corrosion products.

13. High temperature 100% silicone aluminum pigment paints are giving useful service.

14. Epons look good in 3-year tests vs red lead and alkyd finishes. Epons stay on aluminum fan blades in cooling towers, other paints flake off.

15. Hot applied mastics are used only for underwater or underground service. They have some use in damp climates, give best service when applied over primers but appear to require constant repairs.

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API Smoke and Fumes Group Probes Air Pollution

Reactions Producing Ozone Investigated By Institutions

Investigations into the basic chemical reactions among industrial wastes in the atmosphere with the added effect produced by sunlight are underway at ten institutions. These investigations were initiated by the American Petroleum Institute, and are being administered under the jurisdiction of the institute's Smoke and Fumes Committee. Vance N. Jenkins, Union Oil Company of California, Los Angeles, is executive secretary of the committee.

In a report to the refinery division of the API at Houston May 12, Mr. Jenkins explained the organization of the committee, listed the research projects and briefly defined their aims, told which institutions had been engaged to carry them out and told of some of the results of two of the projects so far. The Smoke and Fumes Committee of the Division of Refining was organized during the institute's 1952 mid-year meeting at San Francisco. In 1952 the institute's board of directors approved the soliciting of $250,000 for financing the work of the committee and Mr. Jenkins was named executive secretary effective January 1, 1953.

After interviewing representatives of 13 universities and research organizations, Mr. Jenkins was authorized to enter into contracts for specific investigations. Ten projects have been outlined and work started under contracts with the API.

Progress Is Reported

Mr. Jenkins' report at Houston included comments on some of the discoveries so far in two of the projects. Projects 6.7 which involves a study of the reaction between various nitrogen oxides, nitric acid and other material on the sulfur-dioxide—sulfur-trioxide equilibrium in sunlight has learned that oxidation of sulfur dioxide in the atmosphere in sunlight is a very slow process, only about 0.1 percent being converted to sulfur trioxide in one hour. The project's investigations are continuing with an inquiry into the effect of different types of particulate matter and of the presence of actual water droplets.

Inquiry Into Ozone

Project 6.1 is concerned with the production of ozone in the atmosphere from industrial air pollutants. It also is interested in methods by which the volume of organic pollutants in the atmosphere may be determined. Mr. Jenkins said its initial work indicated.

1. Ozone-free air trapped at night and irradiated by sunlight will produce ozone.

2. Automotive exhaust gas either alone or mixed with oxygen or pure air does not form ozone when irradiated. However, when mixed with air containing a low concentration of ozone it will form irritating products which reduce visibility, irritate the eyes and damage crops in the same manner as smog. The project's work now is in the direction of selective removal from contaminated air of different chemicals, to determine what effect each has.

F. T. Radecke, Shell Oil Co., Wood River, Ill., addressing American Petroleum Institute corrosion session at Houston May 10.

Another part of this project is to develop a commercially feasible device which will detect small concentrations of organic compounds in the air.

Other Projects

The other projects underway include the following: (Titles given here are paraphrases of originals)

6.2—Assessing tracer techniques.

6.4—Quantitative determination of ozone.

6.5—Determining the concentration of hydrocarbons present in effluent gasses from industrial and domestic devices and automobiles.

6.6—Reactions between sunlight and nitrogen dioxide and hydrocarbons in gasoline.

6.6—Investigating the kinetics of the reaction in sunlight with hydrocarbons present in gasoline and determining the amounts and nature of products formed.

6.8—Surveying the ozone content and ozone-forming capacities of selected industrial cities.

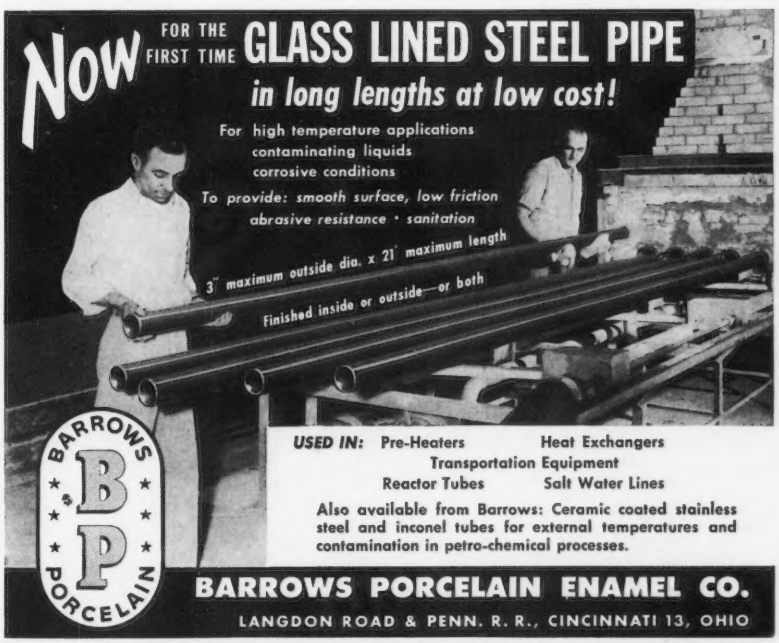
Prevention of Corrosion—

(Continued From Page 26)

of corrosion problems faced in heat exchangers on the cooling water side. His paper, Corrosion and Prevention in Heat Exchangers in Cooling Water Service, consisted of a review of the kinds of corrosion to be expected and measures found effective in controlling corrosion in plants of the Standard Oil Company of New Jersey.

Mr. Munro's principal points were:

1. Water velocity is a primary factor.
2. Temperature control is essential.
3. A safe maximum outlet temperature is 110 degrees F. A thermometer should be fixed at the outlet valve which can be seen readily by the operator so he can keep the temperatures constant by controlling outlet volume.
4. Tube ends are attacked worst.
5. The *vena contract* a effect resulting from the flow characteristics of the incoming water is a phenomenon explaining the characteristic corrosion pattern inside tubes.
6. Trash is the main offender in mechanical problems.
7. Galvanic currents are created by temperature differentials.
8. Materials for each condenser must be selected carefully, and full recognition of the position of the material galvanically with respect to other materials with which it is in contact must be noted.
9. Liquid neoprene linings—in 20-coat systems—have been found helpful in reducing corrosion.
10. Galvanic anodes are used with and without coatings to protect appropriate parts of condensers.
11. Anodes used on curved surfaces must conform to surfaces.
12. Bimetallic tubes are used when necessary with satisfactory service.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NEW PRODUCTS —Materials—Service—Literature

Blakled, a product containing lead and designed to prevent rusting of steel is being distributed by United States Steel Supply Division, U. S. Steel Corp. The company claims it displaces surface moisture and may be applied to wet, brushed rusted surfaces and dry or light mill scaled steel. It dries in an hour after being dipped, brushed or sprayed on.

●

Resistance of Cast Fe-Cr-Ni Alloys to Corrosion in Oxidizing and Reducing Flue-Gas Atmospheres by J. H. Jackson, C. J. Slunder, O. E. Harder and J. T. Gow has been reprinted from ASME Transactions, August, 1953 by the Alloy Casting Institute, Mineola, N. Y. Copies are available on request.

●

Violite, a material of undesignated nature applied in .001-inch thicknesses over coatings will protect them from the effects of ultraviolet radiation and ozone, manufacturers Booker-Cooper, Inc., 6940 Farmdale, North Hollywood, Cal. say. The firm claims accelerated tests have shown the material extends embrittlement point of strippable cocoon material from normal 18 months to 7½ years.

●

Bronze Valves with a new stem material, an aluminum-silicon bronze alloy called Coradur, are being produced by the R-P&C Division, American Chain and Cable Company, Reading, Pa. Dezincification of bronze valves stems, said to be a major corrosion problem, is eliminated by this new alloy, the company claims. Analysis of the material is copper 91%, aluminum 7%, silicon 2%. They are machined from cold drawn stress-relieved rods.

●

Flexonics Corp., 1315 S. Third Ave., Maywood, Ill. is producing new standard and high strength stainless steel straight wall tubings affording substantial weight and material savings over standard designs. It is available in 1 to 6-inch outside diameters in standard grade and from 1.50 to 6-inch diameters in high strength grade. Tolerances are plus or minus .002 or .003-inch.

●

Stainless Steel Wire thread inserts manufactured by Heli-Coil Corp., Danbury, Conn. are recommended when corrosive materials cause unprotected threads to wear, strip and loosen. The inserts are said to reduce the frequency of major overhaul jobs in hot mill rolling from 6 months to 18 months.

●

Roskoter, a machine designed to apply cold mastic to pipes designed by Royston Laboratories, Inc., Blawnox, Pittsburgh 38, Pa. is said to reduce man hours in pipe coating up to 80 percent with a resulting saving overall of 50 percent. The device is a hollow cylinder fitted around the pipe which is then filled with the coating. A film is applied as the machine is rotated.

●

Unitrace, made of extruded Alcoa 3S-F aluminum alloy, combines a product line and an integral but separate line through which heat may be applied to the product line. It is designed to replace lines transporting viscous materials which must be heated by external steam jackets or tubes. The pipe, engineered jointly by Alcoa and Hercules Powder Company, is said to have saved 38 cents a foot over conventional 2-inch steam jacketed lines on material and 30 percent on labor costs. Better heat transfer efficiency is reported. Conventional preformed insulation will fit Unitrace.

●

Allegheny Metal in Chemical Processing, a second edition of a 34-page booklet issued by Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh 19, Pa. is available on request. The booklet is devoted to stainless steels, and includes illustrations, text, tables of data, including numerous ratings versus corrosive media.

●

Ospho, a formula containing orthophosphoric acid and dichromate with extenders and wetting agents is recommended by manufacturers, Rusticide Products Co., 3125 Perkins Ave., Cleveland 14, Ohio for application over rusted surfaces. Applied as a primer the manufacturers say the material converts iron oxide to iron phosphate and provides a good surface overnight drying for application of top coats. It is recommended also for application to new ferrous and galvanized surfaces.

Gates Engineering Co., 100 S. West St., Wilmington, Dela., has put out a new bulletin describing the uses and application of the first air-curing, liquid neoprene protective coating, Gaco N-700. The product gives protection from corrosive fumes and splash and gives general maintenance protection for metal, wood, concrete and other materials. It can be applied by roller, brush or spray.

●

Babcock & Wilcox Co., Beaver Falls, Pa. has issued a new technical data card. Known as TDC 151, the bulletin discusses B&W Croloy 9M (8-10% chromium, 1% molybdenum). The steel is used widely in high temperature service where high corrosion resistance is desirable. Some uses are in handling acidized crudes, high-sulfur corrosive cracking stocks and reforming sour naphthas.

●

Prufcoat Laboratories, Inc., 50 E. 42nd St., New York 17, N. Y. has prepared a colorful brochure describing the latest methods of combining decoration with protection of all types of masonry surfaces, including brick, asbestos shingles, concrete, cement block, stucco and cinder block. Other masonry waterproofings, Pruftite Light-Fast Clear, Pruftite Heavy-Duty Clear and Pruftite Silicone formulations are listed.

●

Tranter Manufacturing Co., Lansing 4, Mich., has issued a report on the use of its Platecoils as employed by 12 different companies. Uses range from heat transfer applications, alkaline stripping and flexseal coating to tar transfer and quench oil cooling. The firm states Platecoils have twice the surface area for a given space and other advantages over similar equipment of different design.

●

The International Nickel Co., 67 Wall St., New York 5, N. Y. has reprinted the results of impact tests of welded austenitic stainless steels. The information is reprinted from The Welding Journal, Research Supplement, Sept., 1950. The tests permit comparison of the effect of weld rods of different analyses and the effect of heat treatments. International Nickel and Metal Goods Corp. have sponsored a series of conferences on corrosion and high temperature alloys. Subjects to be discussed include the properties and applications of alloys designed for use in the high temperature field, the corrosion by acids and other reagents of petroleum and petrochemical units and other topics.

●

Microbiology Service Laboratories, 4419 Fannin St., Houston, has been established recently. Proprietors of the new firm are Mary E. Graham, bacteriologist in the State Health Department's Regional Laboratory and Edna D. Wood, formerly bacteriologist and chief chemist of the City of Houston's Water Division laboratory. As part of the services offered, the firm will make evaluation of bacteriostatic and bactericidal control measures.

(Continued on Page 30)

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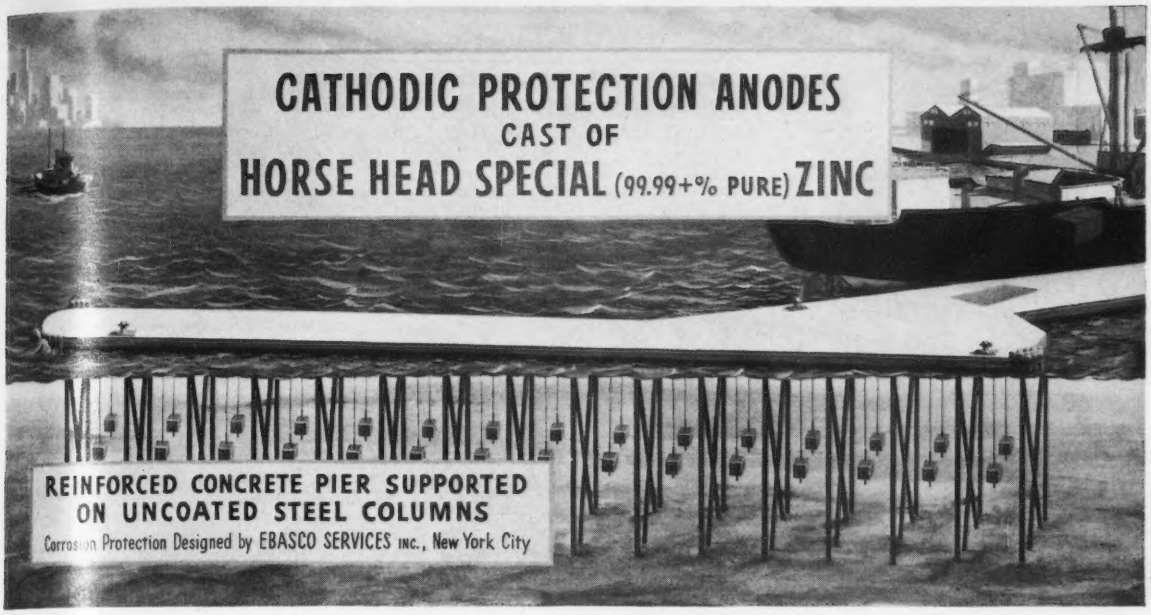
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*250 lb. Horse Head zinc anodes are hung with steel rods from supporting eyes welded to the steel deck structure.

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THE *Chemical* CORPORATION
65 Waltham Ave., Springfield 9, Mass.

NEW PRODUCTS

(Continued From Page 28)

Alcoa Research and Progress in Electrical Conductors, a 20-page, 2-color pamphlet describes and illustrates the numerous pioneering developments and other engineering achievements of the Aluminum Company of America in producing electrical conductors. Copies may be had from the company, 725 Alcoa Bldg., Pittsburgh 19, Pa.

•

Silastic Facts 9-344, a technical data sheet issued by and available from Dow Corning Corp., Midland, Mich. describes the many different formulations of silicone rubber, as to general characteristics, applications and fabrication methods.

•

Clay Pipe was selected by Cadillac Motor Company for sewer lines to handle drainage from chemical plating processes and other acid-containing effluent, according to Robinson Clay Product Co., Akron, Ohio.

•

Steam Tube Dryers 100 feet long by 10 feet in diameter are being made of aluminum with the exception of a steel exterior shell. They are lined with Alcoa 61S alloy plate. The tubes, with 23,700 square feet of heating surface in steam tubes are designed for drying fine solids such as rubber fillers and pigments and were made by General American Transportation Company.

•

Marshall-Wells Imperial, an exterior decorative paint made by Western Paint Company, Duluth, Minn. will not become stained from sulfide fumes, manufacturers say. It also is said to resist staining from rust.

•

Ladcote compounds, a blend of Bakelite polyethylene and 40 percent by weight of wax is applied to kraft paper by Lowe Paper Company, Ridgefield, N. J. to give the paper a high order of resistance to vapor transmission and to acids and alkalies.

•

Empire Steel Castings Inc., Box 139, Reading, Pa. has published a designation chart giving specifications, analysis, physical properties and uses of a number of corrosion resistant and heat resistant stainless steels. It correlates AISI type number and ASTM and SAE designations with Empire Steel and ACI designations. Principal alloying elements are given.

•

Telephone on-off handset switches in units made by Connecticut Telephone and Electric Co., Meriden, Conn. are now wholly enclosed and protected from the elements. The switch opens by spring pressure and closes as a result of the force exerted by a magnet built into the transmitter-receiver when the phone is not in use.

•

Hot-Metal Magic, a 32-page-and-cover booklet produced by Electro Metallurgical Company, a Division of Union Carbide and Carbon Corp., New York City describes the operations of this company which is engaged principally in supplying alloying materials to industry. Illustrations and text describe the handling of the ores, their origin and some of the uses of the finished metals. A part of the booklet, "The Story of the Alloying Metals" describes the origin and use of the principal alloying elements used in modern metallurgy.

•

Calculation of Liquid-Liquid Extraction Process by Edward G. Scheibel, Hoffman-LaRoche, Inc., reprinted from Industrial and Engineering Chemistry, January 1954 has been reprinted and copies are available from the York Process Corp., 69 Glenwood Place, East Orange, N. J.

•

Dorfan Dust and Fume Control Systems, which use a recirculating or parallel flow granule principle to remove smoke, fumes and moisture and for reclaiming byproducts are described in a folder available from Mechanical Industries, Inc., 942 Grogan Bldg., Pittsburgh 22, Pa.

•

Koppers Company uses a special fortified oil in the effluent from its Follansbee, W. Va. tar products plant to remove 99 percent of the phenol from a waste water volume of 100,000 gpd. Installation of a filtration system followed pilot plant experimentation since 1949. Phenol extracted from the waste water is taken from the oil by caustic soda to be sold to partially offset the estimated $30,000 annual operating cost of the treating plant.

•

Unionweld stainless tubing fabricated by means of the gas shielded arc welding method is said by manufacturers not to require annealing after fabrication in several analyses. Manufacturer is Union Steel Corp., Union, N. J.

•

Carboline Company's Bulletin 100 rates various types of coatings according to four classifications of corrosivity of environment. The bulletin then recommends from among the numerous phenolics, furans, neoprenes, vinyls, rubber base resins and epoxies it produces the coating or lining best suited to resist the environment. Information is tabulated on primer requirements, number of coats, surfaces on which applicable, wear resistance, maximum temperature use and other characteristics. A chart gives coverage data in mil feet per gallon for each of the company's products. Average coverage for brush and spray application is given in square feet and film thickness. Copies are available from Carboline Company Division, Mullins Non-Ferrous Castings Corp., 331 Thornton Ave., St. Louis 19, Mo.

•

Crobalite Bulletin 102, available from Crobalt, Inc., 2800 S. State St., Ann Arbor, Mich. describes this company's cobalt-chromium-tungsten hard-facing welding rods for applying high hardness surfaces to steel and cast iron parts which have high resistance to abrasion, corrosion, oxidation and impact. They retain their desirable properties despite repeated heating and cooling to and from temperatures as high as 1600 degrees F.

•

Glass-Fiber Laminates for Shell Structures by A. A. Gassner and Harry Kahn, Gassner Aircraft Engineering, 1860 Broadway, N. Y. 23, N. Y., a study on the fabrication, mechanics, strength, uses, advantages and limitations of this type of structure is available without charge from Lunn Laminates Inc., Oakwood

(Continued on Page 31)

NEW PRODUCTS

(Continued From Page 30)

Road and West 11th St., Huntington Station, Long Island, N. Y. The study includes tabulated and graphed test data and formulae for development of engineering characteristics.

•

Feon No. 287, a spun nylon filter cloth designed for use in filters prone to clog is unaffected by most alkalis and organic acids and will stand up well to strong sodium hydroxide solutions, acetic acid, formic acid and some of the common solvents. It is available from Filtration Engineers, Inc., 155 Oraton St., Newark 4m, N. J.

•

Flexible stainless steel tubing is described in Bulletin STC-1 available without charge from The American Brass Company, American Metal Hose Branch, 698 South Main St., Waterbury 20, Conn. The tubing is made from Types 316 and 321 stainless.

•

Laminates faced on one or both sides with porcelain enamel sheets are gaining acceptance for construction purposes, Seaporcel Metals Inc., 28-20 Borden Ave., Long Island City 1, N. Y. reports. The laminates may have core materials of fiberglas, aluminum honeycomb, paper honeycomb, Celotex, cement-asbestos, Insulcore or plywood. Insulation factors are equal for some of the new materials weighing 6 pounds a square foot to those of comparable masonry walls weighing 100 pounds a square foot.

•

Armorvin, a translucent plastic industrial piping into which is molded a 120-ton tensile helical steel wire, will bend around a 5/16-inch diameter spindle without reducing internal bore. Resistance to water, oil, grease, most acids and alkalies, Diesel fuel, coal and butane gases is claimed, although the nature of the plastic material is not revealed. It is manufactured by Newage International Inc., 235 East 42nd St., New York 17, N. Y.

•

Ampcoflex and **PeeVeeCee** non-plasticized polyvinyl chloride sheets in thicknesses from 10 thousandths of an inch to 2 inches are now available in sheets measuring 9 x 4 feet from Atlas Mineral Products Co., Mertztown, Pa. Welding rod for joining is available to trained plastic welders. Fabricated shapes are available also in these materials.

•

Self-Energized Metallic O Rings are described in a 20-page booklet available from United Aircraft Products, Inc., Dayton 1, Ohio.

•

Cast High Alloys—Properties of the Corrosion Resistant Grades by E. A. Schofer, of the Alloy Casting Institute, Mineola, N. Y. has been reprinted from Chemical Engineering, October 1953 and is available on request from the institute.

•

Ceramic Backing Rings which permit complete root penetration of pipe welds, yet prevent icycles and weld spatter are available from Chemical Equipment Division, General Ceramics Corp., Keasbey, N. J. The shattered ring can be flushed out of the pipe.

•

Acid Buggy, manufactured by Automotive Rubber Company, Inc., 12550 Beech Road at PMRR, Detroit 28, Mich. is designed for the safe in-plant handling of corrosive liquids. Equipped with Saunders type rubber-lined valves, it has a tank rubber lined inside and coated outside. The buggy is complete with wheels, tires, hose, gauges and other accessories. It can be made in several sizes including extra narrow.

•

Coors Porcelain Company, Golden, Col. is producing a new high density mill and tank lining brick said to have high resistance to attack from all acids except hydrofluoric and from strong caustic solutions, especially under high temperature conditions. They are made of a special high density alumina ceramic and are sold by LZP Industrial Ceramics, 2500 West 7th Ave., Denver 4, Col.

Fostoria Pressed Steel Corp., Fostoria, Ohio is manufacturing a magnetically-driven centrifugal pump in which the rotor is driven by a magnetic field. This makes possible complete isolation of the pump interior from the environment outside and eliminates all glands and packing joints. The Dynapump is described in a 4-page bulletin. Standard units are made of stainless steel. The rotor is nickel clad.

•

Acme Protection Equipment Co., 3037 West Lake St., Chicago 12, Ill. has published a list of 433 gases, fumes, mists and dusts of sufficient toxicity to require the use of gas masks by persons working in them.

•

Effect of Temperatures on the Mechani-

(Continued on Page 32)

What are you doing about your share of the nation's multi-million-dollar corrosion debt? Have you investigated the possibility of eliminating corrosion losses in equipment handling water solutions by simple addition and maintenance of small amounts of CHROMATE?

Both hard and soft waters pose corrosion problems. In fact, softening to eliminate scale formation may make the water even more corrosive. Chromate treatment not only prevents corrosion by waters varying widely in quality and purity—in industrial cooling systems, automotive and stationary engines, and air conditioning units—but also may be applied to refrigerating brines, petroleum pipelines and many other instances of continuous contact between water solutions and metal.

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NEW PRODUCTS

(Continued From Page 31)

cal Properties, Characteristics and Processing of Austenitic Stainless Steels, Bulletin A-162 by V. N. Krivobok and A. M. Talbot has been reprinted from the ASTM Proceedings and is available from International Nickel Co., Inc., New York 5, N. Y.

•

Alco Products Review, a periodical published by and available from American Locomotive Co., Schenectady 5, N. Y. published in its Spring, 1954 issue a 9-page article on fabrication of nickel-plated pipe for the Atomic Energy Commission.

•

Infrared radiation at the rate of 100 watts per lighted inch of tube length is produced by a new type lamp developed by General Electric Corp., Lamp Division, Nela Park, Cleveland 12, Ohio. The 500-watt size weighs ¾-ounce and the 1000-watt, 7.8-ounce. The fuzed quartz lamp may be plunged cherry red into water without cracking.

•

Fabricated Pipe, tubing and fittings and modern industrial piping, and descriptions of the size, type and applications of piping available are covered in two recent data sheets issued by Michigan Pipe Co., Bay City, Mich.

•

Fluorothene is now being produced at the Charleston, W. Va. plant of Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corp. Bakelite fluorothene resins, satisfactory over a temperature range of minus 320 to plus 390 degrees F, are composed of fluorine, chlorine and carbon atoms in a chain structure. It is technically a polymer of chlorotrifluoroethylene and is available in three grades, FYTD, FYTH and FYTS, rated according to melt viscosity at 446 degrees F which is in the order of 5, 15 and 50 megapoises respectively.

•

Transistor Transformers measuring ½-inch by 7/17-inch by ⅜-inch in input, interstage and output models are now being manufactured by Telex, Inc., Telex Park, St. Paul 1, Minn. Impedance of the input primary coil is 200,000 ohms with current in the primary coil of 0 milliamperes and impedance in the secondary coil of 1000 ohms; frequently response is down 3 decibels at 200 cycles per second from 1000 cps in the input stage and the maximum power at 200 cps is 0.5 milliwatts.

•

Dacron Filter Cloth, with excellent resistance to acids and caustics at room temperatures is supplied pre-shrunk by manufacturers National Filter Media Corp., New Haven 14, Conn. It is resistant to weak acids even at boiling temperatures and to moderately strong acids at room temperature. It has good resistance to weak alkaline solutions and moderate resistance to strong alkalies at room temperature but is degraded by strong acids at elevated temperatures.

•

Durco Series B fans with capacities to 8000 cfm are designed for service where attack by fumes or other corrosives is likely. The casing is of Duriron and the blade is of Durimet 20, a high nickel stainless steel. They are approximately 40 percent lighter than earlier models but are more efficient and less expensive. Bulletin F/1, available from The Duriron Co., P. O. Box 1019, Dayton, Ohio describes them fully.

•

Eco Engineering Co., 12 York Ave., Newark 1, N. J., is making a centrifugal pump of Carpenter 20 stainless steel with a maximum capacity of 30 gpm. It will pump against a head up to 24 lb. and has a maximum 20-inch suction lift. It is designed for non-contaminating service.

•

Dow Corning 555 Fluid, a water white, odorless material blends readily with such materials as paints, petroleum products and can be used as a plasticizer for certain rubbers, resins and plastics. Its useful temperature range is minus 70 degrees to plus 300 degrees F.

Waterproof Concrete Walls and Floors

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Write for Bulletin 100

DELRAC CORP.

136 Mill St.

WATERTOWN, NEW YORK

PERSONALS

E. R. McClung as assistant plant manager of the American Locomotive Co. at Dunkirk, N. Y., has been announced by E. F. Murphy, manager. Mr. McClung was assistant manager of Alco's ordnance plant in Schenectady.

•

Arthur A. Conrad, Jr., metallurgist, has joined the Detroit Technical Section, Development and Research Div., of the International Nickel Co., Inc.

•

Ralph A. Troupe has been appointed research professor of chemical engineering at Northeastern University. He will direct industry-sponsored research in corrosion and engineering materials. He came to the university from Goodyear Synthetic Rubber Corp. where he was technical superintendent of the Akron plant.

•

Eric Newman has joined Rockwell Manufacturing Co. as manager of the company's export and international division. Mr. Newman, a World War II Royal Air Force veteran, was formerly export manager for William Palfrey, Ltd., London.

•

A. F. McDonald has been placed in charge of the Detroit, Mich. office of Reilly Tar & Chemical Corp.

•

Walter E. Schroeder has been appointed chief engineer of The Colonial Iron Works Co., Cleveland.

•

William P. Drake has been named president of the new Industrial Chemical Division of Pennsylvania Salt Manufacturing Co.

•

Buford Butler has been promoted to sales engineer for pipeline supplies and equipment in the Midcontinent area by Midwestern Engine & Equipment Co., Tulsa, Okla.

•

At a meeting of the board of directors of Standard Pipeprotection Inc., March 9, the following officers were elected: **Howard J. Klossner,** Chicago, chairman of the board; **Hugh W. Baird,** St. Louis, president; **Henry W. Vondrasek,** St. Louis, vice president in charge of operations and **J. B. Wilson,** St. Louis, secretary and treasurer.

•

P. R. Grossman has been appointed chief research engineer with the Research and Development Center of The Babcock & Wilcox Company, Alliance, Ohio.

•

Dan E. Mogenroth has been appointed manager of the General Construction Materials Sales of Owens-Corning Fiberglas Corp.

•

George M. Walker has been named vice-president and general manager of the Koppers Chemical Division.

•

Samuel J. Rosenberg of the National Bureau of Standards has received the Department of Commerce silver medal for meritorious service. The award was made for important contributions to the science and technology of physical metallurgy for over 30 years. He has been a member of the NBS staff since 1920.

•

Joseph S. McCulloch has been appointed manufacturer's representative for the Pennsylvania Salt Manufacturing Company's Corrosion Engineering Products Department in Maryland, Delaware Eastern Pennsylvania and Southern New Jersey.

•

Hugh Glen has been elected president of Johnston Pump Company, Pasadena, Cal.

•

Edward C. Lloyd has been appointed chief of the mechanical instruments section of the National Bureau of Standards.

•

C. W. Poe Co. of Cleveland is a new representative of the Insul-Mastic Corp. of America.

•

James R. Longwell, assistant to the general manager of the Carboloy Dept. of General Electric Company has retired from the organization to head his own sales organization.

Corrosion Abstracts

CORROSION CONTROL — PROTECTS INDUSTRY — NATIONAL ASSOCIATION OF CORROSION ENGINEERS

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Vol. 10 June, 1954 No. 6

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1. GENERAL

1.1 Miscellaneous

1.1, 3.3.4, 5.8.2

The Role of Tannates and Phosphates in the Preservation of Ancient Buried Iron Objects. T. W. FARRER, L. BIEK, AND F. WORMWELL. *J. Applied Chem.* (London) **3**, Pt. 2, 80-84 (1953) Feb.

Archaeological specimens of iron and other materials were found in an excellent state of preservation on a site at Hungate, York after a period of 2000 years. Lack of corrosion was attributable to inhibition of the activity of sulfate-reducing bacteria by tannates present in the soil. Phosphates likewise present assisted by reason of their known corrosion-inhibitive properties. Photographs, table and references.—INCO. 6461

1.2 Importance

1.2.5, 5.2.1, 5.2.3

Does Cathodic Protection Constitute a Fire Hazard? Parts I & II. M. E. PARKER. *Oil Gas J.;* **51**; Nos. 44 & 45; 129, 157 (1953) Mar. 9, Mar. 16.

A discussion on fire hazards associated with cathodic protection which includes hazards associated with the rectifier and with insulated joints in pipe lines, lightning hazards and hazards obtained by breaking or cutting one of the cathodic protection cables and cor-

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CODE OF AGENCIES SUPPLYING CORROSION ABSTRACTS

Neither NACE nor the sources listed below furnish reprint copies.

ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario.

AWWA—Journal, American Water Works Association, Amer. Water Works Asoc., 521 Fifth Ave., New York 17, N. Y.

BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BTR—Battelle Technical Review, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association. 81-91 Euston St., London NW 1, England.

CBEC—Centre Belge d'Etude de la Corrosion (CEBELCOR), 17 re des Drapiers, Brussels, Belgium.

CE—Chemical Engineering, McGraw Hill Publishing Co, 330 W. 42nd St., New York 18, N. Y.

EL—Electroplating. 83/85 Udney Park Road, Teddington, Middlesex, England.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California. 2525 East 37th St., Los Angeles 11, Calif.

IIM—Transactions, The Indian Institute of Metals, 23-B, Notaji Subhas Road, P. O. Box 737, Calcutta, India.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum. 26 Portland Place, London W.#1, England.

JSPS—Japan Society for the Promotion of Science, Address: Mr. Hayata Shigeno, Secretary, Committee of Preventing Corrosion, c/o Government Chemical Industrial Research Institute, 1-Chrome Nakameguro, Meguro-ku, Tokyo, Japan.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.

MI—Metallurgia Italiana, Associazone Italiana di Metallurgia. Via S. Paola, 10, Milano, Italia.

MR—Metals Review, American Society of Metals. 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

NSA—Nuclear Science Abstracts. United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.

PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London. Waldegrave Rd., Teddington, Middlesex.

SE—Stahl Und Eisen, Verlag Stahleisen, M. B. H., Dusseldorf, August-Thysen Str. 1. Postscheck Koln 4110, (22a) Dusseldorf, Germany.

TIME—Transactions of Institute of Marine Engineers, 85 The Minories, London EC 3, England.

UOP—Universal Oil Products. 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association. Lincoln House, Turl Street, Oxford, England.

rection of these hazards. It is felt that cathodic protection and the insulation which is necessary in conjunction with it offer no fire hazard which cannot be overcome by careful design and reasonable operating precautions. Design features and operating procedures are recommended.—INCO. 6522

1.5 Directories of Material

1.5, 6.1

New Engineering Materials. *Product Eng.*, **24**, 139-145 (1953) June.

Discusses use of powdered metals, castings, tubing titanium, ultra thin metals, rubber, laminated plastics, technical ceramics, low alloy permanent magnet materials, high strength steels, rigid PVC, fluorocarbons, aluminum, silicones, large moldings, zirconium and composite metals. Photographs, tables. —BTR. 6459

1.5, 6.1

Annual Engineering Materials Review and Forecast. T. C. Du Mond. *Materials and Methods*, **37**, 101-116 (1953) Jan.

A quick look at developments in engineering materials reveals some changes in use of materials that will be forthcoming and influences that will bring these changes about. Discusses irons and steels; nonferrous metals including high temperature alloys, carbides, copper alloys, aluminum alloys, magnesium, titanium and minor metals, non-metallic materials, parts and forms, finishes and coatings and processing methods including heat treating and joining. Photographs.—BTR. 6406

1.6 Books

1.6, 3.2.2

Gases in Metals. Book, 1953, 204 pp. American Society for Metals, 7301 Euclid Ave., Cleveland, 3, Ohio.

Includes: Fundamental Metallurgical and Thermodynamic Principles of Gas-Metal Behavior, D. P. Smith; Gasses in Nonferrous Metals and Alloys, L. W. Eastwood; Gasses in Liquid Iron and Steel, D. J. Carney and The Behavior of Gasses in Solid Iron and Steel, C. E. Sims.—MR. 6359

1.6, 5.3.1, 5.4.1, 5.9.1

Finishing Handbook and Directory, 1953. Product Finishing. Book, 1953, 511 pp. Sawell Publications Ltd., 4 Ludgate Circus, London, E.C.4. (Free to subscribers of Product Finishing).

This is the third annual edition. Sections on vacuum deposition and on sanding machines have been added. Other subjects covered include preparatory treatments, painting, finishing light alloys, wood and plastics; vitreous enamelling, galvanizing, electroplating, metal coloring, marking processes, directory of trade names, suppliers, etc. —BNF. 6566

1.7 Organized Studies of Corrosion

1.7.1, 2.2.5, 5.4.5

Effect of Coating Thickness on the Performance of House Paints Under Different Programmes of Maintainance. F. L. Browne and D. E. Laughnan. *Official Digest Federation Paint and Varnish Production Clubs*, No. 338, 137-162 (1953).

A report on a 15-year investigation into the performance of house paints, mainly simple oil types, on wood exposure fences. It was found that repainting at short intervals with two coats of paint built up too great a thickness of coating, which then failed by cross-grain cracking and subsequent peeling. The best results are obtained where the repainting frequency was adjusted to balance the rate of loss of thickness of the old paint. This rate of loss of material was found to be a constant of any one paint type for any exposure. The average rates were about 0.5 mils per year for panels facing south and 0.4 mils per year for those facing north, being greater for lead paints than for zinc paints. It is concluded that the optimum initial thickness for house paints systems is about 5 mils, and that on repainting total thickness should be kept down to 7 or 8 mils for southern exposures and 8 to 9 mils for northern exposures. With pure white lead paints a greater tolerance is allowable.—RPI. 6352

1.7.1, 2.2.2, 5.4.5

Co-Operative Research: Exposure Testing on a Co-Operative Basis. A. Pass. *J. Oil Colour Chemists Assoc.*, **36**, No. 394, 151-170 (1953).

The conduct of a large-scale cooperative exposure test carried out by the Zinc Pigment Development Association is described and discussed in relation to the general problems encountered. Particular attention is drawn to the effect of variation in wood, the difficulty of maintaining standards of ratings at different sites or with different observers and the desirability of obtaining complete meteorological data at the actual exposure sites. Methods for condensing the records of degrees of failure to form indices of protective or decorative quality are discussed. Some of the results obtained in the tests are used to illustrate variations in behavior of certain pigments when used in paint films at different places in Great Britain. —RPI. 6607

1.7.2, 7.1, 4.3.3, 4.2.3, 5.8.2

Additive Tests at Pametrada. *Oil Engine*, **20**, 462 (1953) Mid. April.

Note on continued attempt at Pametrada Research Station to inhibit heavy oil deposition and corrosion in the gas turbine by means of additives. After a series of laboratory tests on corrosion of high-temperature metals by vanadium pentoxide at temperatures above 650°C, rig tests were made with metal targets immersed in gasses from compustion chambers operating at atmospheric pressure. Inhibitors used included metallic oxides, water-soluble compounds such as magnesium sulfate and magnesium acetate. Short report on stage of development of the investigation is included.—INCO. 6609

1.7.2

Corrosion: How Inco Fights It. *Iron Age*, **171**, No. 21, 73 (1953) May 21.

At Kure Beach and Harbor Island where Inco tests the corrosive effects of seawater, seaspray and seacoast atmosphere on all types of material, even the chain link fence, consisting of sections of galvanized steel, Monel and aluminum, surrounding the laboratory is tested. A section of the roof is Monel-sheet. In a 4-sided rack partially covered by awning, called the henhouse by Inco's F. LaQue, 5 samples of a given material are placed facing each of the 4 compass points. Each is protected to a different degree by the awning. Of the 20 samples of a single metal, corrosion rates sometimes vary as much as 6 to 1. Illustration.—INCO. 6409

1.7.3

Tube Works Laboratories. *Metal Industry*, **83**, No. 1, 3-6 (1953) July 3.

Description of a new laboratory block at the Yorkshire Copper Works, Ltd. which serves the production in the adjoining works of tubes to a wide range of specifications including deoxidized arsenical and non-arsenical copper, high-conductivity copper, 70:30 brass, 70:29:1 brass, Yorcalbro, 70:30 copper-nickel, as well as other alloys not covered by any external specification. The corrosion laboratory has 9 testing units which were proved successful over a number of years. The chemical analysis laboratory analyzes samples for alloying constituents such as copper, arsenic, aluminum, tin, lead, nickel, iron and manganese. Illustrations.—INCO. 6374

2. TESTING

2.2 On Location Tests

2.2.5, 5.4.5, 4.6.11

Sea Water Immersion Trials of Protective Coatings. J. H. Greenblatt. *Corrosion*, **10**, No. 3, 95-99 (1954) March.

Sea water immersion trials of a variety of types of underwater compositions have shown the superior performance of vinyl finishes, both as protective and antifouling paints. Panel tests have shown that vinyl finishes can be used on cathodically protected hulls and shipboard trials have substantiated this, provided that a controlled cathodic protection system is used. 6478

2.2.4, 8.4.3

Field Testing Can Prevent Flange Leaks. M. R. Jones and F. N. Baldwin, Jr. Petroleum Dev. Co. *World Oil*, **136**, No. 6, 201-203 (1953) May.

Safest and most economical practice for testing flange connections of well head assemblies and drilling hookups is to use the best shoptested flanged equipment available, utilizing secondary seals as sealing insurance, and maintain an effective program of inspection. Thought should be given to a practical means of testing to full test pressures those joints already in service. Two types of secondary seals made of resilient materials, one of which includes a spring steel wire retainer, have been successful. Another type recently introduced is part of the steel gasket. Illustrations.—INCO. 6417

2.2.5, 5.4.10, 8.9.3

A Method for Determining the Resistance of Insulating Joints and Pipe Line Coatings. H. F. Koester. *Corrosion*, **9**, No. 5, 159-162 (1953) May.

A method is given by which the true resistance of both insulating joints and pipe coating can be determined. It combines field resistance measurements and algebraic computations of true resistances. Detailed instructions are given for the placement of test points and the formulae are explained. A special method for use with poorly coated or

uncoated pipe lines is explained. The method outlined has been adopted in the New York City area and has been found satisfactory. 6425

2.2.5, 8.4.3,4.5.1, 5.4.5,7.2

Field Tests of Exterior Coatings for a Pipe Line Conveying Fuel Oil Heated to 200 Degrees F. E. R. STAUFFACHER AND R. R. DAVIDSON, *Corrosion*, **9**, No. 10, 377-381 (1953) Oct.

Field experiments were made to determine a suitable exterior coating for an oil transmission pipe line to handle oil heated to 200 degrees F. The 41-mile line was 8-inch Schedule No. 30 pipe operated at normal working pressure of 600 to 800 psi with three combined heating and pumping stations spaced at approximately 13.5 miles. It was designed to transmit fuel oil from the refineries to a steam-electric generating station.

To test stability, four different coatings were applied to 20 foot lengths of 8-inch pipes connected in series and buried in the soil. Oil heated to 200 degrees F. then was circulated through the pipe for approximately two weeks. Provisions was made to apply an external pressure of 10, 50 and 80 psi by the use of suitable rods and weights at three spots on each of the coatings. Depressions formed were measured carefully throughout the test to determine their rate and magnitude on each coating. Open ditch sections approximately 2 feet long for each coating were provided to permit observation of sag which might take place on any of the coatings. After the experimental hot oil circulation was completed the ditch was opened and the coatings examined for distortion and adherence and electrical resistance measurements were made at the depression points.

Additional 40-foot pipe lengths with each of the four different coatings then were subjected to cold bending by standard field equipment to a total angle of approximately 20 degrees and a minimum radius of approximately twenty pipe diameters (14 feet, 5 inches). After each bend, the coatings were examined for cracks and given "holiday detector" tests to supplement visual examination.

Due to its ruggedness and freedom from distortion during the test it was decided to recommend a ½-inch thick asphalt mastic coating using a 250 degree F melting point asphalt for the hot-oil pipe line exterior coating. 6577

2.2.2, 6.5, 5.8.2

Coatings Cut Corrosion Costs. L. G. JONES. *Power Eng.*, **57**, No. 7, 87-89 (1953) July.

The loss in weight and tensile strength of metals and alloys after 10 years of exposure to various atmospheres are presented in tables. Corrosion preventing inhibitors and the environment in which they are useful are listed as are life expectancies of uncoated bolts, hot dip galvanized coatings and metal coatings. 6649

2.2.2, 6.6.8

Three Years' Outdoor Weather Aging of Plastics Under Various Climatological Conditions. S. E. YUSTEIN, R. R. WINANS (N. Y. Naval Shipyard), AND H. J. STARK (Dept. Navy, Bur. Ships). Paper before ASTM, 56th Ann. Mtg., June 28-July 3, 1952. *Am. Soc. Testing Materials*, Preprint No. 89, 1953, 10 pp.

Investigation of the effects of outdoor weather aging, under widely different climates, on various types of plastic materials including 5 types of clear transparent sheet plastics, 6 types of laminated materials and 5 types of molded terminal bars. Various exposure periods from 1-36 months were used, and various mechanical, electrical, and optional properties were evaluated. On the basis of the extensive data accumulated, it is possible to deduce the occurrance of a wide variety of effects that appear to be related to differences in the climatic and environmental conditions and in the exposure periods. Tables, graphs, illustrations.—INCO. 6516

2.2.5, 5.4.5, 8.1.2

Good Corrosion Resistance of Aluminium Coating on Steel Plate in Sheffield. *Sheet Metal Inds.*, **30**, No. 313, 424 (1953) May.

Brown Bayley Steels Limited's test house was built in 1937. It is about 60 ft. long by 25 ft. wide and the height is 15 ft. in the middle and 20 ft. at one end where there are two stories. The total area of the ½-inch steel plate walls is 2000 sq. ft. In March 1938, the outside surfaces of the steel plates were grit blasted and sprayed with aluminum and a 3-feet dado was overcoated with two coats of black bituminous paint and a single coat of lacquer. In 1939 after the outbreak of war the test house was encased with a sand revetment to a height of about 10 feet. When this was removed in 1946, the coating was virtually intact and it was considered sufficient to repaint the building. Two coats of bituminous paint were ap-

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plied to the dado and above this two coats of an aluminum paint. In June 1952, a Sub-Committee of the BISRA found the aluminum coating in very good condition. Some slight rust-staining could be seen in places and a few rust patches about 1 sq. in. in size were evident but appreciable rusting was evident only at one place about 3 feet wide over a window, where some 10 percent rusting had occurred.

As 15 years is about the maximum life expected for aluminum paint in such a corrosive atmosphere, the test house will soon be repainted. At Abbey Works, Margham, 15,000 to 20,000 tons of steelwork has been shot blasted and given a 0.004-inch sprayed coating of aluminum before painting. It has been stated that this scheme was not more than 2¼ times the cost of the more usual specification of weathering and wirebrushing before the application of red lead primer and finishing paints, the life of which is expected to be 5 years, whereas the life of aluminum sprayed coating may be up to 20 years.—ALL. 6582

2.2.7, 4.6.4

Test Cooling Water for Corrosion by These Methods. M. C. FORBES. Aquatrol, Inc. *Petroleum Refiner*, **32**, No. 4, 130-133 (1953) April.

With the use of specimens such as nipples, coupons or washers, weight loss data may be obtained which will indicate the comparative corrosive properties of cooling water streams. From these data, the corrosive properties of cooling water may be roughly classified as slight, considerable, or serious. Testing procedures and interpretation of the tests are covered. Tables.—INCO. 6426

2.3 Laboratory Methods and Tests

2.3.2, 2.4.2

Accelerated Weathering Devices. R. H. SAWYER. Devoe & Reynolds Co., Inc. Paper before ASTM, Symp. on Conditioning and Weathering, 55th Ann. Mtg., N. Y,. June 24, 1952. ASTM Special Publication No. 133, 1953, 91-98.

Laboratory tests developed for accelerated weathering conditions are discussed. Mechanical weathering machines and limitations of accelerated tests are discussed. Mr. F. L. LaQue (INCO) reports that the salt spray test is not well suited to the measuring of the behavior of stainless steels in the atmosphere, or in any environment except that encountered in a salt spray testing machine. 6 references.—INCO. 6487

2.3.4, 4.3.2, 3.5.9, 4.4.1

Corrosion by Acids at High Temperatures. R. F. MILLER, R. S. TRESEDER, AND A. WACHTER. *Corrosion*, **10**, No. 1, 7-12 (1954) Jan.

A test method is described for obtaining corrosion data with acids and other corrosives at temperatures above their normal boiling points. The method, which has features of simplicity and general usefulness, involves use of a flame-sealed heavy-wall glass tube as container for the metal specimen and corrosive fluid. The atmosphere over the fluid can be controlled and, by evacuating the tube before sealing, can be made to consist only of the equilibrium vapor at test temperature. It is estimated that the tubes withstand gas pressures up to about 1000 psig which corresponds to a test temperature of 285 degrees C for water. Appropriate test safeguards are described.

Corrosion data obtained by this method are presented for various alloys exposed to sulfuric acid, phosphoric acid, nitric acid, formic acid, boric acid and phenol at different temperatures and concentrations. An interesting general observation from these corrosion data is the relatively good corrosion resistance of copper in sulfuric, phosphoric, boric and formic acid solutions. 6636

2.3.4, 2.3.7

Utility of Strauss Test. L. H. SATZ. General Electric Co. *Metal Progress*, **63**, No. 1, 136, 138 (1953) Jan.

Success of $CuSO_4 \cdot H_2SO_4$ corrodent, used in the Strauss test depends on the passivating effect of the concentration of $CuSO_4$. Work of other mentioned authors suggesting the utility of $CuSO_4 \cdot H_2SO_4$ solutions for the corrosion testing of steels is discussed. Graph.—INCO 6520

2.3.6, 6.2.5, 2.3.7

Screening Stainless Steels from the 240-Hour Nitric Acid Test by Electrolytic Etching in Oxalic Acid. M. A. STREICHER. E. I. du Pont de Nemours & Co., Inc. ASTM Bulletin, No. 188, 35-38 (TP27-TP30), (1953) Feb.

Electrolytic oxalic acid etch as a screening test for the 240-hour boiling 65% nitric acid test. Steels which, in this etch, show little or no evidence of attack due to carbide precipitation at grain boundaries are not subject to rapid intergranular corrosion and need not be tested in nitric acid but steels which, on etching, show appreciable intergranular attack must be tested in nitric acid to determine if the resulting degree of intergranular susceptibility is within that permitted by the maximum nitric acid rate for the given steel. This test is applicable to AISI Types 304, 304L, 316 and cast 18-8, 18-8 molybdenum and FA20 steels but not to Types 321 and ELC 316. The test may eventually be used for Type 309. Illustrations, 8 references.—INCO. 6637

2.3.7, 3.2.3, 4.3.5

Velocity of Action of Oxygen, Hydrogen Sulfide and Halogens on Metals. G. TAMMANN and W. KOSTER. *Z. anorg. u. allgem Chem.*, **123**, 196-201, 208-224 (1922) Aug. National Advisory Committee for Aeronautics, Tech. Mem., No. 1339, June, 1952, 21 pp.

A method of determining the rate of surface oxidation of a metal by the change in the color of the surface film produced by reactions with oxygen, chlorine, or iodine is discussed. The metals studied included iron, nickel, copper, zinc, cadmium, tin, lead, cobalt and manganese. Tables are given for surface film thickness versus color for various times, for iron, nickel and copper in nitrogen-oxygen mixtures and for b(a constant for determining the retardation in the thickening of the oxide coating with increased time) for iron and nickel in air and b for copper in oxygen and air. Graphs, 5 references.—INCO. 6354

2.3.7, 2.4.3

Testing the Porosity of a Paint Film on a Conducting Substrate. K. A. PANHAUSER. *Farbe u. Lack*, **59**, No. 2, 56 (1953).

A portable apparatus is described for detecting porosity in paint films on metal. It comprises a wire electrode set in an isulated handle and charged to 15-20 kv from a 4 v accumulator through a coil. A lamp, included in the circuit, glows when the electrode discharges at a fault in the film.—RPI. 6449

2.3.7, 6.2.3

Improvements in Test Method for Determination of Susceptibility of Steel to Stress-Corrosion Cracking. (In German). W. RADEKER. *Stahl und Eisen*, 73, 485-490; Disc. 490-492 (1953) April 9.

Account of investigations on structural steels with and without aluminum. Stress-corrosion cracking was determined after long-time tensile tests at elevated temperatures in boiling solution of calcium-ammonium nitrate. Effects of stress, alkaline concentration, temperature of solution, heat-treatment and welding, upon stress-corrosion cracking and technique for determination of cracking rate are discussed.—INCO. 6549

2.3.7, 2.6, 1.6, 2.3.9

Procedures in Experimental Metallurgy. A. U. SEYBOLDT AND J. E. BURKE. Book, 1953. John Wiley & Sons, Inc., New York; Chapman & Hall, Ltd., London.

Interest on the part of physicists and physical chemists in doing experimental work revealing fundamental information about metals creates the need for expanding the available information on reliable procedures. The authors present details of technique, equipment, control and lists of materials for various kinds of tests on metals.

Chapters include: Methods of Obtaining High Temperature, Measurement of High Temperatures, Control of Temperatures, Refractories, More Controlled Atmospheres, Vacuum Systems, Metal Melting and Casting, Heat-Treating Techniques, Fabrication of Metals, Powder Metallurgy, Preparation of Pure Metals and Preparation of Metal Single Crystals.

The book is illustrated and indexed. 6532

2.3.9, 4.3.6, 6.2.5

Radiography as an Aid in Corrosion Studies. H. A. LIEBHAFSKY AND A. E. NEWKIRK. *Corrosion*, **9**, No. 11, 432-435 (1953) Nov.

The value of radiography in qualitative corrosion studies has been demonstrated by applying this x-ray technique in an investigation of the corrosion of three types (302, 317, 347) of stainless steel by ferric chloride solution. Parallel photographs and radiographs were obtained for comparison. The radiographs show striking differences in the corrosion patterns for the different steels under different conditions. 6407

2.3.9, 1.3

Radioactive Materials in Finishing Research, *Product Finishing*. **6**, No. 3 56-63 (1953).

A review of the use of radioactive materials for investigating electroplating, vitreous enamelling, paint and paint films and corrosion problems.—MA. 6506

2.4 Instrumentation

2.4.2, 6.2.3, 4.6.7, 3.5.11

Corrosion of Mild Steel Moving Rapidly in Salt Solutions and Natural Waters. F. WORMWELL, T. J. NURSE and

EVEN THE TOUGHEST ACIDS Shun this Joint

In acid-proof brick floors — in any type of corrosion-resistant masonry — the joint between the bricks is the critical point. Ordinary mortar joints won't do. Even many specialized "acid-proof" cements will handle only a limited range of acids. Others will handle acids but fail quickly under alkali attack.

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375-D

H. C. K. Ison. *J. Applied Chem.*, **3**, Pt. 6, 275-280 (1953) June.

Use of high-speed rotor apparatus for corrosion tests at speeds of 32.7 ft./sec. on uncoated specimens is described. The passivity, characterized by relatively noble potentials, of mild steel moving rapidly in fresh water, was studied. Weight-loss/time curves were obtained at 25° for mild steel in sodium chloride solutions and natural and artificial seawater. Rate of corrosion of mild steel increases with concentration of sodium chloride up to the maximum value (0.5N) investigated. Rates of corrosion in seawater are high, although lower than those in 0.5N sodium chloride. Graphs, tables and 8 references.—INCO. 6616

2.4.2, 8.9.3

Equipment for Conducting Survey. *Oil Gas J.*, **52**, No. 4, 115 (1953) June 1.

View of an anode and cathode area, discovered during a corrosion survey along a pipe line, is shown. By the use of an earth current meter, the intensity of the action at these anodes and cathodes is determined. From the readings obtained, the intensity and direction of the current flow are calculated.—INCO. 6509

2.4.2, 3.5.9

Apparatus for Rapid Determination of Liquid-Liquid and Liquid-Solid Equilibria Involving Corrosive Materials. W. Davis, Jr., L. L. Conley, and G. P. Rutledge. Union Carbide & Carbon Corp. *Rev. Sci. Instruments*, **24**, No. 6, 431-432 (1953) June.

An apparatus was built for measuring temperatures at which phase changes (precipitation of solid or liquid from a homogeneous solution) are visually observed to occur. It was constructed for use with corrosive chemicals, such as anhydrous hydrogen fluoride, which are contained in a fluorothene tube. The tube has appropriate thermal shielding and is shaken vigorously to allow relatively large rates of heating and cooling. Precisions of temperature measurement in the order of ± 0.5°C are attainable.—INCO 6361

2.4.3, 8.9.3

Submarine Corrosion Finder. *World Oil*, **136**, No. 6, 270L (1953) May.

An easy-to-make calomel electrode is an effective instrument for making surveys of underwater pipe lines—especially those in off-shore salt water. Its case can be constructed to withstand mild underwater pressures and to resist a certain degree of contamination due to direct contact with salt water. For negative buoyancy, lead shot is lodged in the bottom section between two rubber stoppers. Illustration.—INCO 6645

2.4.3

Fluorescent and Magnetic Inks for Flaw Detection. *Mech. World*, **133**, No. 3403 59 (1953).

The uses of three fluids are given as follows: a) Supramor, electromagnetic flaw detection ink for the detection of internal and surface flaws in magnetizable metals; b) Glo-mor fluorescent ink for indication of surface cracks and porosity in any metal and c) Lumor, a fluorescent magnetic ink.—MA 6405

2.4.3

Ultrasonic Inspection of Thin Metallic Sheet or Plate. R. Wilson. *Sheet Metal Inds.*, **30**, 146-160 (1953) Feb.

Outlines recently developed method particularly applicable to sheet or material of relatively thin cross section. Graphs, diagrams, and micrographs. 10 references.—BTR 6599

2.4.3

Experimental Comparison of Different Methods of Detecting Cracks by Penetration of Fluids. H. de Leiris. *Rev. Met.*, **50**, No. 3, 159-168, disc. 168-169 (1953).

In recent years a number of new and more effective methods of detecting cracks appearing at the surface of metal parts have been devised. They fall into two main classes: in one the use of strongly wetting and highly colored liquids gives rapid results; in the other maximum sensitiveness is obtained by fluorescence. De Leiris investigated experimentally how far these methods and their variants are interchangeable. The materials used both for impregnation and detection by different workers vary greatly. For detection, Moutet (Congres National de l'Aviation Francaise, Rep., 1946) used a suspension of calcium carbonate, de Leiris dry talc powder, Matte and Lachenaud (*Tech. moderne aviation*, **4**, No. 8 (1948) Fuller's earth either dry or in colloidal suspension with methanol. For impregnants: as solvents, Moutet used butyl lactate + toluene, de Leiris a tetraline-toluene-propyl alcohol mixture, Matte and Lachenaud paraffin + oil; as colorants, rhodamine (Moutet), organol red B. S. (de Leiris), and dimethylcoeroxenol acetate (Matte and Lachenaud). The surfaces of the specimens were degreased and dried or covered with a film of light oil, water, or oil-water emulsion. In all cases operations consisted of drying, impregnating the cracks, soaking and detection and observation of the cracks. The sensitiveness and rapidity of the method were increased by the use of talc instead of Fuller's earth and by indirect lighting by Wood's lamp through a yellow filter, using Moutet's impregnant but this latter can only be used in a laboratory.—MA. 6436

2.4.3, 8.9.3

Spot-Checking Corrosion. D. H. Stormont. *Oil Gas J.*, **51**, No. 45, 75 (1953) March 16.

The immersion ultrasonic inspection technique can be applied to lines and vessels impossible to actually immerse by directing a stream of water on the surface according to preliminary tests carried out by D. C. Erdman of Electro Circuits, Inc., at the Taft compressor station of Southern California Gas Company. Tests demonstrated that the equipment could rapidly detail how much corrosion had occurred and whether laminations, inclusions or density flaws existed in either metal or weld. Cross-section views of the metal beneath the scanning crystal were shown on a television-type cathode-ray tube. Where defects showed up on the screen, the image was photographed for a permanent record. Adaption may soon result in a new tool for determining in the field the extent of corrosion inside pipe lines and vessels and for inspecting pipe-line welds. 6569

2.4.3

Electronic Measurement of Surface Coating Thickness. *Product Finishing*, 6, No. 3, 47-50 (1953).

A description of the circuit and method of operation of a relatively simple electronic apparatus for measuring the thickness of non-magnetic coatings on magnetic bases and of detecting pinholes in non-conductive coatings on conductive bases.—MA. 6568

3. CHARACTERISTIC CORROSION PHENOMENA

3.2 Forms

3.2.3, 3.5.9, 1.6

Oxidation of Metals and Alloys. O. Kubaschewski and B. E. Hopkins, Book, 1953, 239 pp. Butterworths Scientific Publications, London.

The authors of this book are both in the Metallurgy Division of the National Physical Laboratory. Dr. Kubaschewski is well known for his work carried out in Germany on the thermo-chemistry of metallic reactions and Mr. Hopkins had experience in an industrial research laboratory before joining the National Physical Laboratory.

They form a strong team for dealing with the problems of oxidation and have produced a lucid and authoritative statement which incorporates a great deal of information not previously collected.

The object of the book is to provide a clear statement of the principles governing the oxidation and scaling of metals and of the factors which influence the mechanism and rate of attack.

The book thus has a somewhat academic atmosphere, but will be invaluable to anyone concerned in the development of heat resisting alloys.

The marine engineer is faced with problems of scaling in firebox parts, and to some extent in Diesel engines and will certainly be faced with more difficult problems in the development of the gas turbine. This book will give him a clear picture of the processes at work. It will not necessarily provide him with an account of all the practical information which has been gained, thus, although there is a good summary of the reasons for the bad effects of vanadium oxide in ash from fuel oil, the oxidation of cast iron is not dealt with at all.

To the metallurgist or the marine engineer engaged in high temperature research the book will be a necessity. To others it will be a luxury.—TIME. 6347

3.2.3, 5.6.3, 6.3.11

Tarnish and Corrosion Prevention. *Chem. Age* (London), **68**, 921-923 (1953) June 20.

Summarizes report of recent investigations by Design and Research Centre for Gold, Silver and Jewelry industries, reviewed in Report No. 15. Hydrogen sulfide absorbent paper, named "TarnO Tissue" (patent pending) has been investigated by independent bodies, and results of findings are summarized. 10 gm. of tissue decontaminate approx. 30,000 cu. ft. of air in an average city atmosphere (Canadian city). Apparatus used for test is described. Test specimens consist of pure silver sheets 2 x 1-inch, supported on glass frames. Hydrogen sulfide concentrations of 0.075 and 0.038 percent used with similar quantities were

added at the end of every 24 hours. Paper effective in retarding tarnish of silver wrapped in tissue under conditions of 44-100 percent relative humidity, effect being more marked at higher humidities. Tissue suspended in room will condition this and retard tarnishing of silver and electroplate placed in the room. Other research was concerned with prevention of rusting during storage of mild steel cutlery and flatware blanks. Two possible methods are coating with proprietary strippable gelatine film or to use a vapor-phase inhibitor. Shell VPI 260 is used for latter method, which is to be preferred.—INCO. 6351

3.2.3, 3.5.9, 3.8.4

Oxidation of Metals at High Temperatures. WALTER J. MOORE. Indiana Univ., May 1, 1953, 23 pp. *J. Electrochem. Soc.*, **100**, No. 7, 302-313 (1953) July.

The available data on the oxidation rates of pure metals from 300 to 1000°C have been analyzed in terms of concentrations of defects in the oxide structures and defect diffusion coefficients. Quantitative agreement with the diffusion theory is obtained in the cases of **p**-type oxides such as cuprous oxide and nickel oxide, in which cationic vacancies arise by solution of oxygen at the oxide-oxygen interface. The parabolic oxidation rates in the cases of some **n**-type oxides, such as zinc oxide and zirconium oxide, are characterized by low activation heats and large negative activation entropies. In some of these cases anionic diffusion seems likely. In the case of zinc oxide, the diffusion of radiozinc during oxidation supports the cationic diffusion mechanism. The data on linear oxidation rates fall into two classes; evidence is presented to show that one class represents reaction at the oxide-oxygen interface and the other, reaction at a metal-oxygen interface.—NSA. 6386

3.2.3, 3.8.4, 3.7.2

Metallic Oxidation. A Simplified Treatment. U. R. EVANS. *Research*, **6**, No. 4, 130-137 (1953) Apr.

Discusses types of oxidation curves, mode of passage through the film, formation of holes, oxidation theories, copper in oxygen at 1000°C, sulfide and iodide films, influence of boundary reaction, effect of internal boundary reaction, burning of metals, acceleration of attack by molybdenum and sulfur and retardation of attack by alloying constituents. Graphs. 53 references.—BTR. 6414

3.3 Biological Effects

3.3.2, 8.9.5

Influence of the Surface and Surface Reactions on the Fouling of Ship Bottoms. M. RAGG. *Farbe u. Lack*, **59**, No. 1, 17-20 (1953).

The paint surface/sea water interface is of predominant importance in fouling. The first stage in fouling is the attachment of semi-microscopic organisms, bacteria, diatoms and algae, to form a primary slime. This is due to the tendency of hydrophobic substances to reduce their high surface energy (arising from the difference in dielectric constant between surface and water) and might be prevented if a hydrophilic surface sufficiently water-insoluble were known; certain hot-applied coatings (not specified) approach this ideal. Cypris larvae of barnacles attach themselves by means of a hydrophilic proteinaceous secretion which does not change the surface energy, but in presence of heavy metal toxins, heavy metal salts are formed which are hydrophobic and so promote further fouling and also reduce toxicity. The existence of an electrically charged surface may be of some importance. Thus, most surfaces are negatively charged (by adsorption of OH^-) in water; exceptions are those containing amido groups. The negatively-charged surface attaches sea water metal ions and toxin ions and may be a factor in slowing down rate of release of toxins. Fouling organisms are generally negatively charged, but certain parts (e.g., antennae) are positively charged and hence are readily attached. It was thought that such organisms would be repelled by a positively-charged surface, but on test with a polyamide resin plate, this was found not to be true. However, electrical charge, as well as color, may play a minor role in promoting toxic action of anti-fouling paints.—RPI. 6585

3.3.4, 8.9.3, 4.5.1

Bacteriological Control—A Manual on Underground Corrosion, Columbia Gas System Service Corp. *Oil Gas J.*, **52**, No. 8, 113 (1953) June 29.

Modern concept of bacterial corrosion is that bacteria causing changes in the physical and chemical properties in the soil either produce active galvanic cells, or by destroying the protective hydrogen ion film which would normally collect along the cathode surface of a galvanic cell reduce its activity. A method for predicting the presence of these bacteria isn't necessary because any resulting corrosion will be of the galvanic type. If the proposed location for the new line is inspected for ordinary galvanic corrosion and the pipe line reinspected after it has been in service, it can be determined whether or not new corrosive areas were added due to the presence of anaerobic bacteria. Corrosion control is discussed. —INCO. 6384

3.4 Chemical Effects

3.4.3, 3.2.2, 4.3.6, 5.8.2, 6.2.3

Corrosion of Steel in Dilute Solutions of Sodium Salts of Weak Acids. M. J. PRYOR. *Corrosion*, **9**, No. 12, 467-477 (1953) Dec.

It was found that the exposure of steel specimens to dilute solutions of common anodic inhibitors such as sodium carbonate, sodium silicate, disodium phosphate and trisodium phosphate, free from and containing a small concentration of potassium chloride, could result in either general attack, localized attack or pitting—the later being obtained only in carbonate chloride solutions. It was suggested that the nature of the corrosion product largely controlled the form and rate of corrosion. A corrosion product of high permeability and low resistance, such as lepidocrocite, permitted general attack, under cathodic control, at practically a constant rate, whereas more impermeable corrosion products of higher resistance, such as goethite and vivianite, greatly reduced the rate of corrosion which was mainly under anodic control. Experiments carried out in a divided cell, designed to simulate conditions present during localized attack and pitting, indicated that the effect of the small concentration of chloride was to greatly reduce the internal resistance of the corrosion cells. This effect was considered to be due to the greater ease of migration and diffusion of chloride ions through the corrosion products which, in effect, resulted in a decrease in their resistance. 6539

3.4.6, 6.2.3, 6.3.6, 4.6.1

The Corrosion of Mild Steel and Brass in Chlorinated Water. F. WORMWELL AND T. J. NURSE. *J. Applied Chem.*, **2**, Pt. 12, 685-692 (1952) Dec.

Corrosion of mild steel and brass sheet in flowing water was investigated. Results are discussed in relation to the effect of chlorination, rate of flow, period of test and temperature. The effect of chlorination (up to 0.4 ppm free chlorine) of the various waters was not marked, either for mild steel or brass. An appreciable increase in the rate of corrosion of brass was observed in one raw hard water and in another water the corrosion of brass was increased by chlorination at water speed of about 50 ft/sec. Tables, photographs and references.—INCO. 6356

3.4.8, 6.2.5, 3.7.2, 6.2.4

Sulfide Resistance of Chromium Steels. W. L. NELSON. *Oil Gas J.*, **51**, No. 43, 101 (1953) Mar. 2.

Chromium in steel is about the only element that acts specifically in reducing sulfide corrosion. Although small additions of silicon and aluminum increase the resistance of chromium steels, they cannot be used in even small amounts without adverse effects on the physical properties of most steels. Plain molybdenum (carbon-molybdenum) and low-nickel steels are, under some conditions, attacked more actively by sulfide corrosion than the plain carbon steels. Applications and the effect of temperature on sulfide corrosion are briefly discussed. Tables.—INCO. 6502

3.4.8, 6.3.6

The Relative Effect of Traces of Hydrogen Sulfide and Sulphur Dioxide on the Corrosion of Copper. J. BYRNE, M. D. KAHN, H. B. KRISTINSSON AND C. O. MADDOX, JR. *Blast Furnace Steel Plant*, **41**, No. 7, 780-781 (1953) July.

Work described resulted from an effort to alleviate severe corrosion conditions in a control-room for a 75-inch tandem rolling mill. Corrosion was evidenced by a black layer on the commutators and busbars. On the basis of qualitative evidence, it was concluded that traces of hydrogen sulfide are far more corrosive to copper than are traces of sulfur dioxide. Qualitative test procedure for hydrogen sulfide is given., 4 references.—INCO. 6363

3.5 Physical and Mechanical Effects

3.5.8

Friction, Friction Oxidation, and Fatigue Cracking of Metals. (In German). W. SPATH. *Metall*, **7**, 34-36 (1953) Jan.

Shows that if 2 metallic surfaces are moved against one another under pressure, high local temperature occurs which can momentarily reach the melting temperature of the metals. Friction oxidation is signified by galling of local areas and subsequent shearing. Fatigue cracking is explained by combined effect of destructive "melting-off process" and healing of welds.—BTR. 6517

3.5.8, 8.9.5

Brittle Structural Failures with Emphasis on Welded Ships. J. O. ALMEN. Gen. Motors Corp. *Product Eng.*, **24**, No. 4, 192-203 (1953) April.

Experiences and results of experiments to support the theory that welded structures fabricated from ductile steel fail by brittle fracture. Data show that susceptibility to the several common causes of brittle fractures in ductile metal such as fatigue, stress corrosion cracking and biaxial tension can be reduced by the development and retention of residual compressive stress in vulnerable areas. Simple methods for reducing harmful residual stresses are given. Since welded ships are fabricated from ductile steel and the fracture origins of failed ship plates are brittle in character, ship failures are suspected of developing from several causes. Stress corrosion cracking of magnesium and stress corrosion failures in steel are discussed. Tables, graphs and 15 references.—INCO. 6370

3.5.9, 3.2.3, 2.4.2, 3.5.8

Determination of High Temperature Fatigue Limit in Ordinary and Controlled Atmospheres. G. VIDAL. *Rev. Met.*, **50**, 21-33; disc. 33-34 (1953) Jan.

Complex mechanism of rupture at high-temperatures cannot be clarified except through examining, either singly or at one and the same time, effects of creep, fatigue and corrosion. Consideration of part played by creep and observations on role of corrosion are given. Attack by gaseous media produces surface distribances classified into four distinct zones. Examples of surface disturbance relate to: atmospheric attack on Nimonic 80 (16 hr. at 1300°C and 8 hr. at 1080°C from unpublished work by Buckle); attack of petroleum gases in oxidizing atmosphere on Nicral D (23% chromium, 18% nickel) tests in special apparatus for 50 hr. at 1000°C. (from unpublished work by Galmiche); and oxidizing attack of ordinary atmosphere on cobalt-chromium-molybdenum alloy (50 hr. at 1000°C from unpublished work by Galmiche). Original work on Per 2 (French reproduction of Nimonic 80) showed considerable surface attack when tested for 300 hr. at 850°C in the Galmiche apparatus in kerosene containing surfur under conditions of alternating oxidizing and reducing combustion. Recapitulation of Poulignier's and Jacquet's experiments on ATGS (another French reproduction of Nimonic 80) is given. Notes on mechanical effects of surface corrosion and effects of rising temperature on creep- and fatigue- resistance of Nimonic 80 are included. Results of these tests were used to underline necessity for new approach to fatigue effects as criterion of behavior at high temperatures. Alternating tensile-compression equipment for determination of high-temperature fatigue limit in ordinary, neutral or corrosive atmospheres is discussed. Furnace involved is very long and narrow, special clamps are constructed of one of the following materials, according to temperature at which it is desired to operate: Chromium-Molybdenum steels, 18/8, modified 18/8, 80/20 nickel-chromium, cobalt-base, aluminum or aluminum-chromium alloys. Application to tests on alumium at 300°C, cobalt-base alloys (unspecified) and chromium-aluminum alloys is described and results compared with values for Nimonic 80.—INCO. 6588

3.5.9, 5.3.4, 5.4.2, 1.3, 4.2.3

Protective Coatings on Metals. D. M. DOVEY AND K. C. RANDLE. General Electric Co., Ltd. *Metal Treatment & Drop Forging*, **20**, No. 95, 341-345 (1953) Aug.

Surface coatings play an important part in increasing the life of metals and alloys at high temperature particularly in the presence of fuel-ash constituents in high-velocity gas streams. Methods of providing these protective coatings, either metallic or ceramics are discussed. The applications and future developments in this field are also reviewed. Table, photomicrographs and references. —INCO. 6450

3.5.9, 6.6.6, 6.7.2

A Contribution to Present Knowledge of the Resistance of Sintered Alumina to Corrosion. GUSTAV JAEGER AND ROLF KRASEMANN. *Werkstoffe u. Korrosion*, **3**, 401-415 (1952) Jan.

The present work contains, in part, some quantitative contributions on the resistance of crucibles, made of tightly sintered alumina, to corrosion when exposed to the action of aqueous solutions, such as acids and bases, as well as acid and basic reagents. In addition, details of numerous experimental fusions are given, which show the behavior of sintered alumina (Degussit Al 23), at temperatures up to 1,800° C, in the presence of a number of substances which are of importance in industry. These substances include glass, slag, iron scale, as well as refractory and other materials. 6560

3.6 Electrochemical Effects

3.6.5

Fundamental Concepts of Electrode Potentials. ANDRE J. DEBETHUNE. *Corrosion*, **9**, No. 10, 336-344 (1953) Oct.

The potential differences observed at metal liquid interfaces arise as a result of two distinct phenomana: 1) at reversible electrodes, phenomena associated with Faraday's Law; 2) at polarized electrodes, phenomena associated with the charging of the double layer. At reversible (or nearly reversible) electrodes, electricity can flow through the interface by the mechanism of an electron exchange reaction between the metal and the chemicals present at the electrode surface. When electrons are donated by the metal (reduction), the electrode is a cathode. When electrons are removed by the metal (oxidation), the electrode is an anode. When electron exchange is at equilibrium, the electrode potential is governed by the Nernst equation. A kinetic derivation of this equation is given. Its two terms, the standard potential term and the Mass Action term, are discussed. The standard hydrogen electrode (SHE) provides a convenient reference point from which to measure electrode potentials. The conventions regarding the signs and nomenclature of electrode potentials are reviewed.

With a net current flowing, the electron exchange is not at equilibrium and the potential of the electrode is displaced from the reversible Nernst value (polarization potential). Polarization as an anode shifts the potential in a more noble direction; as a cathode, in a less noble direction. The application of cathodic polarization to the cathodic protection of a metal is discussed. The properties of the electrical double layer at an ideal polarized electrode are surveyed both from the point of view of the potential of zero charge (the isoelectric point of the electrode) and from the point of view of the differential capacity of the double layer. 6578

3.6.6, 6.4.2, 6.3.6, 8.9.2

A Case of Corrosion in Light Alloy by Galvanic Coupling. (In French) P. A. JACQUET. *Rev. Aluminium*, **30**, No. 200, 217-224 (1953) June.

Intense scaling on a piece of aluminum alloy of unknown composition in contact with the copper-alloy radiator of a motor car; the feeble galvanic couple was thought to be responsible for the formation and penetration of cracks. —BNF. 6424

3.6.8, 3.8.3, 6.5, 3.6.5, 3.4.8

Polarization and Passivation in Corrosion of Metals. W. KATZ. *Metall*, **7**, No. 5/6, 161-170 (1953) March; *Z. Metallkunde*, **44**, No. 3, 108-112 (1953) Mar.

The article deals with the electrochemical reaction mechanism; the anodic and cathodic polarization curves; the relation between the current potential and polarization curves; shapes of current potential curves (silver, cadmium, zinc, tin, iron nickel, copper); effects of layer formation current (voltage) potential curves, oxidation substances and secondary particles in steel; the temporary structure of layers followed up on the course of potential (iron in phosphate solutions, zinc in phosphate and bicarbonate solutions); passivation symptoms on lead, iron and titanium. The potentials occurring during corrosion on metal surfaces are due to and greatly influenced by various electrochemical processes and very often they include such wide potential ranges that they can no longer be derived or explained by the basic voltage line or Nernst formula. The enlargement on the significance of these laws, as applied at times to metals without their own metal ions or in such small concentrations as become effective during corrosion, might lead to wrong conclusions. Under corrosive circumstances the regulating circumstances are almost exclusively taken on by other electrochemical effective components of the solutions and not by the metal ions themselves. The circumstances of the potential can be explained by the polarization of the local element planes, whereby a graphical representation can be successfully applied. The potentials occurring on metal surfaces during corrosion are removed by layer formation and pore-effects within the layers by the stable potentials of the clean surfaces by polarization effects of the element activity so that passivation symptoms or unexpected increases in potential become possible even in common metals. Two diagrams show the potential behavior of aluminum. One shows the polarization of the inhibition process of aluminum in 10 percent common salt solution with an addition of sodium chromate and a second diagram shows the polarization curves of aluminum in 3 percent sodium chloride solution saturated with air, and airfree. —ALL. 6590

3.6.8

The Effect of Ultrasonic Waves on Hydrogen Overvoltage. E. YAEGER, T. S. OEY, AND F. HOVORKA. Western Reserve Univ. Paper before ACS Symp. on Electrode Processes, Nat. Mtg., Atlantic City,

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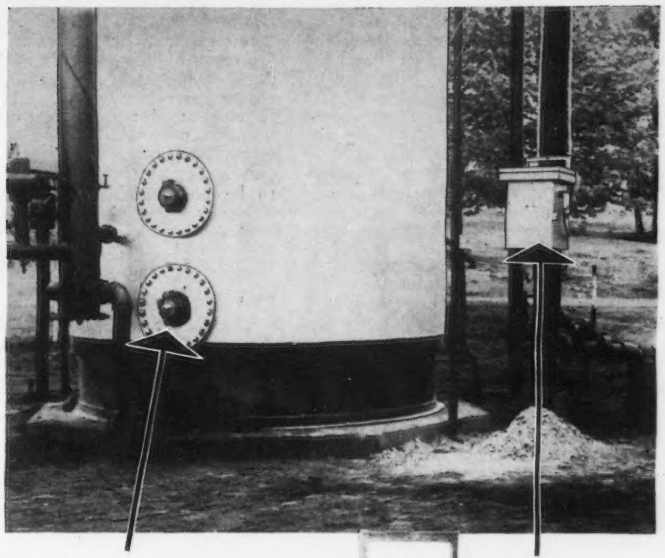

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Sept. 1952. *J. Phys. Chem.*, **57**, No. 3 268-275 (1953) March.

Investigation was made to study the effect of ultrasonic waves on hydrogen overvoltage in terms of a bright platinum surface. Smooth platinum was chosen since there is some agreement as to the nature of hydrogen overvoltage on this surface. For platinum in acid medium the discharge of the hydrogen ion to yield adsorbed atomic hydrogen is believed to be essentially reversible at moderate current densities while the combination of atomic hydrogen to form molecular hydrogen is rate determining. Polarization measurements were made by the indirect method with an electronic commutator and gated potentiometer. Graphs and diagrams.—INCO. 6570

3.6.9

Stray-Current Corrosion—A Manual on Underground Corrosion, Columbia Gas System Service Corp. *Oil Gas J.*, **52**, No. 6, 151 (1953) June 15.

Stray current corrosion in electrified railway systems is illustrated and described. The force causing the corrosion is the same as that developed by the galvanic cell, but the electric drive or electric force behind it is greater than the maximum forces that can be developed in a galvanic cell. Method for locating positive and negative areas along the surface of an underground structure such as a pipe line is given. When stray currents are in the vicinity of electric street railway, it is sometimes convenient to take the potential profile by measuring the potential difference between the pipe line and the rail of the street-car system.—INCO. 6387

3.7 Metallurgical Effects

3.7.3, 5.9.4, 6.5

Many Common Metals Successfully Heat-Treated in Steam. F. L. SPANGLER. *Materials and Methods*, **37**, No. 1, 85-86 (1953).

Tempering, annealing and stress relieving in steam atmospheres prevents the formation of scale on non-ferrous metal and gives a corrosion-resistant blue-black oxide film on ferrous metals. The latter is tough and porous, will hold lubricants and is corrosion resistant.—EL. 6518

3.7.3, 6.2.5

The Welding of Equipment in Chromium-Nickel Austenitic Steel. F. H. KEATING. *Welder*, **22**, 61-69 (1953) Apr.-June.

Discusses development of sigma phase, reduction of corrosion resistance, reducing impact resistance at sub-zero temperatures, welding techniques, heat treatment and finishing treatments. Micrographs.—BTR. 6411

3.7.3, 6.2.3, 5.3.2, 5.11

The Corrosion Resistance of Fusion Welding on Steels. E. KLOSSE. *Werkstoffe u. Korrosion*, **4**, No. 5, 172-178 (1953) May.

Investigations on the corrosion resistance of small autogenic welded test pieces show a difference in their resistance from welds made on large pieces in actual practice. Reasons are investigated and explained. Alterations in the structure of the steel due to the heat of the welding operation can sometimes prove favorable to corrosion. Peculiarities in design can lead to corrosion. Occurrence of stress corrosion in welded joints and pitting are investigated. Influence of autogenic welding of steel on its corrosion resistance is explained. Instructions for preserving corrosion resistance, particularly from a design and operating angle, of acid-resistant and non-scaling steels are given. Precautions to be observed during the welding of ordinary steel plates and steel plates coated with anti-corrosive agents (chromium and galvanizing) are given.—INCO. 6419

3.7.4

The Effect of Grain Size of the Powder on Behavior of Sintered Iron During Nitriding. (In German). WERNER KOSTER AND JOSEF RAFFELSIEPER. *Arch. Eisenhuttenw.*, **23**, 225-228 (1952) May-June.

Effects of grain size on absorption of nickel, on density, on rate of sintering and nitriding, and on nitriding temperature are indicated. Behavior of the sintered product during machining, its corrosion resistance, and its hardness are discussed. Tables and graphs.—BTR. 5970

3.7.4, 6.5

Structure and Corrosion. G. V. AKIMOV. *Metal Progress*, **63**, 230, 232 (1953) Jan. [Translated and condensed by A. G. Guy from Izvest. Acad. Nauk S.S.S.R., Section of Chemical Sciences (Bull. Sci. U.R.S.S.), **1951**, 469-480, Sept.-Oct.]

For abstract of original article see card No. 4315, classified 3.7.4, 6.5.

3.8 Miscellaneous Principles

3.8.2

Recent Views on the Relationship Between Electrochemical and Chemical Corrosion. (In German). A. BUKOWIECKI. *Chimia.* (Switz.), **6**, No. 7, 156-165 (1952) July.

Recent studies with metals, such as zinc, iron, copper, nickel and lead in contact with solutions of varying electrolytic capacity have led to a new concept of the relationship between electrochemical and pure chemical corrosion. Electrochemical corrosion, predominant in strong electrolytes, can occur also where the metal is in contact with a weakly conducting solution. Conversely, reactions of a purely chemical nature predominant in nonelectrolytes can also appear in aqueous solutions having considerable electrical conductivity. Consequently, there is no sharp distinction between electrochemical and purely chemical corrosion, it is often merely a question of formal description or of purely hypothetical considerations rather than the result of experimentally established facts. The two processes may often overlap or transform into each other. It would be more appropriate to distinguish between corrosion which is predominantly due to electrochemical processes involving ions and electrons, and corrosion which consists primarily of a chemical reaction between metal atoms and molecules of the attacking medium. The formation of galvanic cells on the metal surface by electrochemical action does not, in itself, constitute a greater danger to the metal than does purely chemical corrosion. It becomes dangerous only when it leads to localization of the attack. Local attacks can, however, develop even in weak electrolytes. —PDA. 6077

3.8.2, 3.7.2, 3.6.2, 5.8.3

Rust. M. RAGG. *Werkstoffe und Korrosion*, **3**, No. 3, 102-105 (1952) Mar.

Damages caused by rust on iron constructions and the resulting costs are discussed. The old chemical theory of rusting and the newer electrochemical one, as well as the influence of inclusions of foreign particles in the iron, causing formation of local cells and currents are related. Description of a model-local-cell iron/carbon and the measuring of the electric potential in it is given. Formation of iron/hydrogen alloys on the iron surface and the dissolving of steel plates in hydrochloric acid are discussed. Investigation of the behavior of the Sacred Iron-Column at Delhi, iron-chains at Adamspeak, iron objects in the Egyptian pyramids, and iron constructions in high mountains and experiments of the corrosion committees in different climates is reported on. Remarks are included on the passivating effect of oxygen, acid and alkaline passivity, natural and artificial passivity films, and passivity of coatings.—INCO. 6191

3.8.3, 2.3.4, 6.2.2, 4.3.2

Passivity of Iron in Nitric Acid. HARRY C. GATOS AND HERBERT H. UHLIG. *J. Electrochem. Soc.*, **99**, 250-258 (1952) June.

Passivity of iron in nitric acid was studied employing iron films evaporated on glass. Discusses influence of pre-exposure to various types of environments on the precise amounts of iron dissolving in nitric acid before passivation reaction practically ceases. 13 references.—BTR. 6123

3.8.3, 6.2.2

On the Passivity of Iron. K. F. BONHOEFFER. *Z. Metallkunde*, **44**, No. 3, 77-81 (1953) Mar.

Description of various phenomena associated with passivation and reactivation in concentrated nitric acid. Apparent and actual passivation potential, effects of current density including effects of Redox system, role of nitrous acids in passivation by concentrated nitric acids, corrosion of passive iron, resistance to activation, and rhythms and activity waves are discussed.—INCO. 6226

3.8.3, 6.2.5, 2.3.5, 3.7.4

Stainless Steel Research Work—3rd Note: On the Passivity of the Austenitic Steels—18/8. A. FERRI. *Metallurgia*, **45**, 203-207 (1953).

The author, after a brief foreword on the phenomenon of passivity reveals the importance which, in the mechanism of the phenomena themselves, the superficial state of the metal and also the crystallographic orientation has.

The author then passes on to describe the apparatus and the method of research by which he was able to experimentally demonstrate (with electrochemical measurements on 18/8 steel) that the passivity—apart from depending on external factors (the nature of the electrolyte), from the state of the metallic surface and from the intrinsic chemical and electrochemical properties of the metals—is also a sensitive function of the tendency of the metals themselves to absorb oxygen or air.—MI. 6401

3.8.4, 3.7.4, 3.4.6

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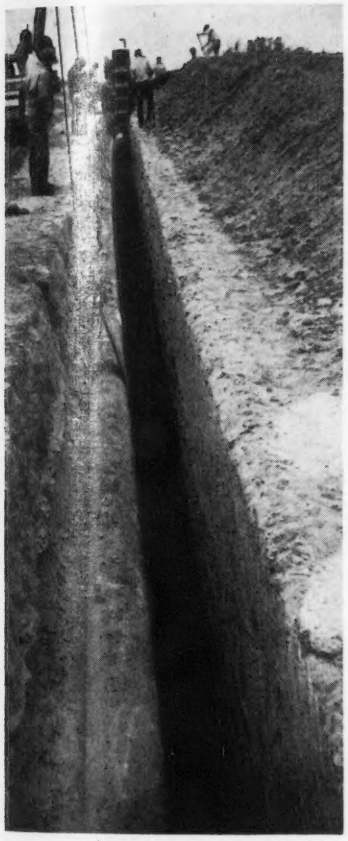

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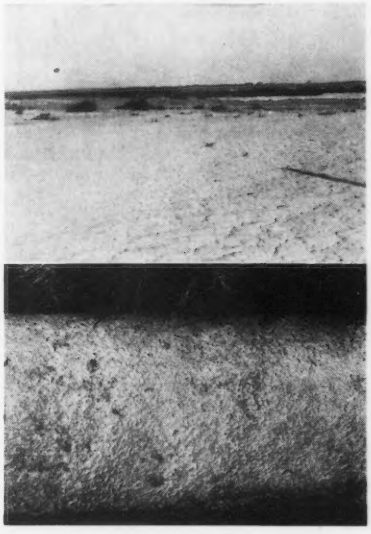

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on Fresh Metal Surfaces. L. GRUNBERG. *Proc. Phys. Soc.* (England), B. **66**, No. 399, 153-161 (1953) Mar. 1.

The recent discovery by Kramer that freshly exposed metal surfaces emit electrons is considered to be the cause of the of the Russell effect and of Shaw's mechanical activation. Electrons originating from the surface initiate reactions involving free radicals. With water, in the presence of oxygen, this leads to the formation of hydrogen peroxide. Metals were cut under water containing oxygen and it was found that, under similar conditions, zinc, aluminum, magnesium and nickel yield approximately the same quantity of hydrogen peroxide. Iron gives ferric ions and copper only very little hydrogen peroxide. During cutting, considerable quantities of hydroxides become suspended in the solution. With zinc, more hydrogen peroxide is formed per cut in the early stages of the experiment, owing to the exposure of fresh surface by the dissolution of zinc hydroxide. In the latter stages each zinc atom exposed is responsible for the formation of approximately 1.5 molecules of hydrogen peroxide. The decomposition of hydrogen peroxide in the presence of chips of zinc is found to be a pseudo-unimolecular process. The cutting of copper in a solution of ferrous ions yielded ferric ions. The amount of ferric ions produced seems to depend on the quantity of oxygen available in the solution.—ALL. 6355

3.8.4, 6.3.19, 4.3.5

The Kinetics of the Dissolution of Zinc in Aqueous Iodine Solutions. Parts III and IV. A. C. RIDDIFORD AND L. L. BIRCUMSHAW. *J. Chem. Soc.* (London), **1952**, 698-704, February.

In Part III, zinc, copper, amalgamated copper, brass, lead, and nickel were found to dissolve in aqueous iodine solutions at the same rate under the same experimental conditons. Observed rate of dissolution of zinc was independent of crystal face exposed to attack, but was a function of the rate of stirring. Results agree with Levich's theory. In Part IV, the fluid flow is discussed. The reaction may be used to characterize fluid flow in other solid-liquid systems. —BTR. 6192

4. CORROSIVE ENVIRONMENTS

4.2 Atmospheric

4.2.3, 7.6.4, 8.2.2, 5.7.9

The Influence of Certain Smokes and Dusts on the SO_3 Content of the Flue Gases in Power-Station Boilers. P. F. CORBETT AND D. FLINT. *J. Inst. Fuel*, **25**, No. 149, 410-417, 446 (1953) May.

It is shown that external corrosion of heat exchanger surfaces due to sulfur trioxide in flue gases may be reduced by increasing the dust burden of the flue gases. In the first series of tests, zinc-containing smokes were added to the flue dust; acid dew points and acid buildup were greatly reduced or eliminated for the duration of the addition. In the second series, auxiliary pulverized fuel firing was introduced, resulting in lowering the surface temperature at which peak rates of acid deposition and corrosion occurred and in markedly reducing the corrosive effects of the flue dust. Some suggestions as to the mechanism of this action are given. The tests and results are described in detail. Tables, graphs, and 23 references. 6357

4.2.4, 6.4.2, 8.1.2

Resistance of Aluminum Alloys to Chemically Contaminated Atmospheres. W. W. BINGER, R. H. WAGNER, and R. H. BROWN. *Corrosion*, **9**, No. 12, 440-447 (1953) Dec.; *Modern Metals*, **9**, No. 3, 66-68, 70-72 (1953) April.

The excellent resistance of aluminum alloys to atmospheric weathering is well known and has been used to advantage for many years in architectural applications and general metal work. Because of this characteristic, considerable interest has been shown in aluminum alloys for plants and industrial buildings where the atmosphere is contaminated by fumes and chemicals that promote the corrosion of many metals and alloys. Of the many factors connected with atmospheric corrosion problems in chemical plants, refineries and other industries those encountered most often are combinations of hydrogen sulfide, carbon dioxide, sulfur dioxide, hydrogen chloride, moisture and dirt. In general, it has been found that aluminum alloys are resistant to atmospheres containing these contaminants. In addition, the problem in most plants is further aggravated by the formation of dust and/or fumes. An active laboratory as well as field testing program is continuing to demonstrate that aluminum alloys of the type used for architectural applications are very resistant to corrosion by a wide variety of organic and inorganic chemicals. The use of aluminum-base alloys in the coke, soda ash, sulfur, power, paper, salt, petroleum and petrochemical industries has reduced corrosion losses with resultant savings in maintenance costs. Some of the applications where aluminum alloys have proved successful are tank roofs, siding, roofing, windows, duct work, ladders, handrails, instrument tubing and tread plate. 6295

4.3 Chemicals, Inorganic

4.3.2, 3.5.9, 6.2.5, 6.4.2

Corrosion of Aluminium by Nitric Acid as a Function of Temperature is Summarized in Chart Form. MARS G. FONTANA. *Ind. and Eng. Chem.*, **45**. No. 2, 93A-95A (1953) Feb.

"Isocorrosion" charts given with this article show the corrosion of aluminum by 0 to 100% nitric acid as a function of temperature. Aluminum is rapidly attacked at concentrations below 80% even at low temperatures, but above 80% corrosion resistance increases. This applies mostly to 2S aluminum, high purity commercial aluminum (99.6% minimum) and 3S alloy. High strength alloys such as 14S, 17S, and 24S or "Dural" type materials fall into this picture only for the strong acid at lower temperatures. Aluminum equipment such as cooling coils, condensers, piping, hoods, ducts, storage tanks, tank cars, and drums are used in the manufacture and handling of strong nitric acids. A corrosion chart for 18-8S stainless steel is given for comparison with aluminum. This latter metal is superior for use with dilute acids, but aluminum is more resistant to the stronger acids, at above room temperature.—ALL. 6117

4.3.2, 6.2.2, 5.8.3, 5.8.4

Studies on the Inhibition by Amines of the Corrosion of Iron by Solutions of High Acidity. C. C. NATHAN. *Corrosion*, **9**, No. 6, 199-202 (1953) June.

The present paper describes studies carried out on the corrosion of both steel strips and iron powder in solutions of 1 normal hydrochloric acid. These studies have been directed toward the evaluation of various aliphatic and aromatic amines as corrosion inhibitors and to the correlation of the structure of the amines with their adsorption characteristics and inhibitor efficiencies. It has been found that the effectiveness of the amines increases with molecular weight in the homologous series and that steric factors which would appear to be more favorable for the adsorption of the amine or its ion at the metal to solution interface increase the inhibition effeciency. These factors are discussed in detail. The series of amines investigated were the aliphatic straight and branched chain, aniline and its homologs, and N-alkylated derivatives, alkylated pyridines and pyridine homologs, and several dibasic aromatic amines. 6158

4.3.2, 6.2.5

Holding Down Corrosion. *Steel*, **132**, No. 6, 96 (1953) Feb. 9.

Corrosion-resistant stainless steel No. 20 (29% nickel, 20% chromium, 3% copper, 2% molybdenum) is proving itself under extended exposure to hot sulfuric acid for 3747 hours. Made in ½ in. rods it handles about 50 gallons of sulfuric acid a minute in full solution range from 0.58% concentration. At Carpenter Steel Co. it is used in 78% sulfuric acid at temperatures up to about 50°C and in all other concentrations at temperatures to about 80°C. The product resists boiling sulfuric acid in concentration up to 10%. The firm uses it in manufacturing solvents, plastics, chemicals and synthetic rubber.—INCO. 6132

4.3.3, 6.3.10

Piping Hot Caustic Soda. *Steel*, **132**, No. 4, 92 (1953) Jan. 26.

Difficulties in transporting hot caustic soda solutions will be surmounted by the use of a 10,000-foot long wrought nickel piping system which will carry solutions at temperatures around 600°F. Even at these high temperatures, nickel corrosion rate by caustic soda is less than 0.020-inch per year. More than 2700 feet of Heliarc welding is done on the entire operation. Photograph.—INCO. 6144

4.3.3, 4.2.3, 3.2.3

An Investigation of Accelerated Oxidation of Heat Resistant Metals Due to Vanadium. FOREST C. MONKMAN AND NICHOLAS J. GRANT. *Corrosion*, 9, No. 12, 460-466 (1953) Dec.

The anticipated increase in the use of crude fuel oils containing vanadium in high temperature installations has initiated further experimentation concerning the nature of accelerated oxidation caused by the action of certain oxides of the metals vanadium, molybdenum and tungsten on heat resistant alloys at elevated temperatures.

The effect of additions of various refractory metal oxides on the physical and corrosive nature of a vanadium oil ash has been investigated to determine the possibility of oxide additives as a method of preventing accelerated oxidation. Oxidation tests were also con-

ducted to determine the effect of some of the major constituents of oil ashes on accelerated oxidation.

Since a solution to the problem of accelerated oxidation may be best accomplished through a knowledge of the oxidation mechanism, chemical analysis and X-ray diffraction stduies were conducted on the oxide scale formed during the accelerated oxidation of Type 347 stainless steel in contact with liquid vanadium pentoxide. The metal-oxide interface was found to have the highest level of oxidation and the highest vanadium concentration. Also at this interface, X-ray diffraction evidence was found for a vanadium-oxygen-metal compound having the formula MVO_4. 6586

4.3.3, 7.2, 6.3.10

Heliarc Welding Helps Fabricate Nickel Pipe. *Welding J.* (N. Y.), **32,** No. 8, 743 (1953) Aug.

Hot caustic soda solutions used by one chemical manufacturer flow through a new, Heliarc welded wrought nickel piping system fabricated by the Gulf Coast Fabricating Co., Houston. Piping system carries caustic soda solutions at temperatures around 600° F and higher. Nickel is used for the system since it has excellent corrosion-resistance properties.—INCO. 6610

4.3.6

Corrosive Effects of Deicing Salts. TP-19 Corrosion by Deicing Salts. *Corrosion,* **10,** No. 1, 3-6 (1954) Jan.

Deicing salt used in cities in the Northern part of the United States is estimated to cause an added $100,000,000 annual loss to automobiles and buried pipes and cables. Tests are related showing the effect of deicing salts on steel exposed to various concentrations of salts and the effect of inhibitors on reducing the corrosive effect of the salt. Various suggestions concerning the recommended mitgation practices for automobiles and underground power and communications cable and equipment are given. The lack of quantitative data on deicing salt corrosion losses and the need for additional research are emphasized. 6486

4.4 Chemicals, Organic

4.4.2

Itaconic Acid by Fermentation with Aspergillus Terreus. V. F. Pfeifer, C. Vojnovich, and E. N. Heger. Northern Regional Res. Lab. *Ind. and Eng. Chem.,* **44,** No. 12, 2975-2980 (1952) Dec.

Itaconic acid, produced by fermentation of corn sugar with Aspergillus terreus, is discussed. Fermentors are constructed of Type 302 and 347 stainless steel. The filtered liquor is also contained in stainless steel kettles. Tables, flow sheet and 45 references.—INCO. 5935

4.4.2, 3.5.9, 3.4.4

Composition of Vapors from Boiling Binary Solutions: Pressure Equilibrium Still for Studying Water-Acetic Acid System. D. F. Othmer, S. J. Silvis, and A. Spiel. Polytechnic Institute. *Ind. and Eng. Chem.,* **44,** No. 8, 1864-1872 (1952) Aug.

At temperatures below 250°F., the equilibrium still body, constructed of Type 316, was completely resistant to the corrosive action of the boiling water-acetic acid solutions, but at temperatures above 250°F., a reddish brown colora-

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tion of the solutions gave evidence of the attack. The severity of corrosion increased with increase in temperature and with increase in acetic acid concentration. The product of corrosion in no way interfered with the analysis. Diagrams, tables, graphs and 28 references are included.—INCO. 5977

4.4.6, 6.2.4, 5.8.2

Corrosion of Steels by Kerosene and Methods of Prevention. I. N. PUTILOVA, L. G. GINDIN, E. V. ARTAMONOVA AND V. A. KAZAKOVA. *J. Applied Chem.* (USSR) (Zhurnal Prikladnoi Khimii), **26,** No. 2, 148-154 (1953).

Low-alloyed steels are corroded in tractor kerosene by organic acids formed owing to auto oxidation with atmospheric oxygen under catalytic action of the metal surface and by dissolved or emulsified water present. Analysis of the corrosion products shows that they consist predominantly of salts of trivalent iron and organic acids and only 10 percent of rust. Removal of polar compounds, i.e. the acids and water, retards but does not completely prevent formation of corrosion centers. Addition of sodium benzoate inhibits rusting in the aqueous layer. Certain organic compounds containing chlorine, sulfur, amino or hydroxyl groups, but otherwise not identified, confer some immunity when added to kerosene by lengthening the induction period and retarding the corrosion process. 6553

4.4.7, 2.3.2, 5.8.2

Chemical Addition Agents for Lubrication Oils. W. D. THOMAS. Am. Cyanamid Co. *Petroleum Refiner,* **32,** No. 1, 103-106 (1953) Jan.

Superior type lubricants have overcome problems in the design of new high output engines. Two types of chemical additives controlling physical properties of the oils are described. The sulfonates are the most widely used detergents in crankcase oils today. For measuring the effectiveness of inhibitors and detergents, laboratory engine tests were developed which correlate with field experience for the type of service intended. Tables and five references.—INCO. 6146

4.5 Soil

4.5.1, 3.3.4

An Investigation of the Corrosive Effects of Soils on Steel Plates. G. D. GEMMELL. *New Zealand J. Sci. Technol.,* **33B,** 287-298 (1952).

Laboratory tests show no simple correlation between corrosion and any one soil property. A soil with a resistance of 3000 ohm cm. or less is probably highly corrosive. The higher the moisture equivalent the greater the corrosiveness. Corrosion due to anaerobic sulfate-reducing bacteria is most severe in neutral soils. 6088

4.5.3, 2.2.6, 6.2.2, 6.2.4

Corrosion of Low-Alloy Irons and Steels in Soils. IRVING A. DENISON and MELVIN ROMANOFF. *Corrosion,* **9,** No. 4, 141-149 (1953) April.

The results of measurements of the corrosion of 10 low-alloy irons and steels exposed to 14 soils for periods up to 13 years are given. The magnitude and progress of corrosion as determined by weight-loss and pit-depth measurements are correlated with the composition of the materials and the nature of the environmental conditions to which the test specimens were exposed. 6120

4.5.3, 5.3.2

Corrosion of Galvanized Steel in Soils. IRVING A. DENISON and MELVIN ROMANOFF. *Corrosion,* **9,** No. 4, 132-141 (1953) April.

The results of measurements of the corrosion of galvanized steel and of bare steel and zinc as reference materials after exposure to different soil conditions for a maximum of 13 years are reported. The magnitude and progress of corrosion of galvanized steel as determined by weight loss and pitting is interpreted in terms of the environmental conditions to which the specimens were exposed. From analysis of data on the corrosion of galvanized specimens having different weights of coating, minimum coating requirements for different environmental conditions are suggested. 6087

4.6 Water and Steam

4.6.2, 2.2.3, 7.4.2, 8.2.2

Contamination of Condensate by Heat-Exchanger-Tube Alloys. J. D. RISTROPH, Virginia Electric & Power Co. and E. B. POWELL, Stone & Webster Eng. Corp. Paper before ASME, Ann. Mtg. N. Y. Nov. 30-Dec. 5, 1952. *Trans. Am. Soc. Mech. Engineers,* **75,** No. 5, 729-738; disc. 738-745 (1953) July.

Results are presented from condensate contamination studies conducted at Virginia Electric Bremo and Chesterfield power stations to evaluate the influence of temperature of condensate, of differing dissolved gas content and of cumulative service time upon the degree of metallic contamination to be expected in steam condensate of the general character described from flowing contact with tubing of 12 alloys used in power-plant heat exchangers. Alloys included phosphorized copper, 88-10-2 copper-zinc-tin, Admiralty, aluminum bronze, aluminum brass, 90-10 copper-nickel, 70-30 copper-nickel, Monel, and 316 stainless steel. Influence of cyclohexylamine on the rates of contamination is indicated. The testing procedures are briefly described. Part of the discussion is by F. L. LaQue. Graphs, tables, and 10 references.—INCO. 6625

4.6.2, 5.7.1

Water Treatment Engineering—Chemicals Used in Water Conditioning. L. W. FITZPATRICK. *Power Eng.,* **57,** No. 2, 74-75 (1953) Feb.

Selection of chemicals for sound water conditioning is based on two considerations—economy and efficiency. Soluble calcium salts are treated with phosphates. Final selection of the phosphate is based entirely on economics and boiler water alkalinity. Oxygen is the most common cause of corrosion affecting any part of the system. Mechanical deaeration and sodium sulfite effectively minimize this corrosive agent. Organic materials used are lignins, tannins, starches and seaweed compounds and their derivatives. Most organic compounds contain added corrosion inhibitors, antifoam agents and embrittlement inhibitors. Tables.—INCO. 6430

4.6.4, 5.8.2

Corrosion Control in Cooling Water Systems. W. A. TANZOLA. W. H. & L. D. Betz, Inc. *Petroleum Engr.,* **25,** No. 4 C 57-C 60 (1953) April.

Effectiveness of the Dianodic method of reducing pitting in recirculating cooling water systems is compared with straight chromate and straight phosphate treatment. Method which consists of a combination of 2 anodic inhibitors (polyphosphates and chromates) at relatively low concentrations under controlled conditions of pH reduces pitting to a fraction of that produced with each material used separately. Results of this method which have been followed in most field applications by the exposure of steel specimens in the system are tabulated and discussed. Weight loss on steel specimens coupled to admiralty specimens is tabulated and the effect of deposits and suspended solids on corrosion load is discussed. Tables, 4 references.—INCO. 6596

4.6.2, 8.1.1

Heating Terminal at Greater Pittsburgh Airport and Air Conditioning Terminal Building. T. F. ROCKWELL. *Heating, Piping, Air Conditioning,* **24,** No. 12, 77-80 (1952) Dec.; ibid, 25, No. 2, 79-83 (1953) Feb.

Features of the design and the reasons for them are explained. The boiler house is 1300 ft. from the terminal building and out of the normal flight pattern. A chemical feed pump is provided for each boiler which introduces a treatment compound consisting of an organic colloid to control sludge, phosphate to control hardness, sulfite to control pitting, and an alkali to control the pH of the boiler water. A separate chemical feed pump is used to introduce a filming amine into the feedwater for the purpose of coating the inside of the return piping to inhibit internal corrosion. Corrosion detectors were installed in the return lines to give indications of the rate of corrosion. Photographs.—INCO. 6130

4.6.4, 5.7.9,

Use of Surface-Active Agents in Cooling-Tower Water Treatment. W. F. OXFORD, JR. Sun Oil Co. Paper before Natural Gasoline Assoc. of America, Ann. Mtg., Houston, April 20 1952. *Petroleum Processing,* **7,** No. 5, 620-622 (1952) May; *Oil Gas J.,* **50,** No. 51, 176-177, 263-264 (1952) May 5.

Surface-active agents are used fairly extensively in preventing scale and corrosion in the circulating cooling-tower water of gas-compressor plants. It was found that a mixture of high-molecular-weight substituted glyoxalidines, known as Kontol, and acylated amino alcohols, known as SP-8, is very effective in controlling scale and corrosion. Graph. 6 references.—INCO. 5885

4.6.6, 8.1.4, 1.2.5

Control of the Treatment of Water in Building Piping Systems. ANDREW T. DEMPSTER, Director, Bureau of San. Eng., Detroit, Mich. *J. Am. Water Works Assn.,* **45,** No. 1, 81 (1953) Jan.

Three possible methods of eliminating the health hazard due to over-dosages of chemicals used for scale and corrosion prevention in building piping systems are: 1. Banning chemical water treatment in private systems, 2. making additional treatment unnecessary by

treating at the municipal plant and 3. regulating methods and equipment and licensing qualified personnel to supervise the supplementary treatment process. The author discusses the regulatory method put into effect by the City of Detroit.—NALCO. 6106

4.6.4, 3.4.6, 5.8.2, 4.6.11

A Contribution to the Study of the Action of Certain Inhibitors Upon Corrosion in Chloride-Polluted Water. W. S. PATTERSON AND A. W. JONES. University of Durham. *J. Applied Chem.* (London), **2**, No. 5, 273-280 (1952) May.

The corrosive action of sea water which sometimes enters the cooling system of marine Diesel engines can be retarded by employing a corrosion inhibitor in the cooling system. A limited study was made of the effectiveness of potassium dichromate, sodium nitrite, sodium benzoate and two soluble mineral base oils in inhibiting the corrosion of steel, copper, tin and cast iron in 0.75% sodium chloride solution and dilute sea water. Oils No. 1 and No. 2 contained 20% and 40% emulsifiers, respectively. Samples with an exposed area of 50 sq. cm. were immersed for 21 days in 200 ml of a quiescent solution usually at 30°C and weight losses determined.

With the exception of potassium dichromate, there was a critical threshold concentration above which there was good corrosion inhibition of steel, but below which there was considerable attack. The threshold values for sodium nitrite, sodium benzoate and the soluble oils were 0.25%, 2.5% and 0.1% respectively. Below these values sodium nitrite and the soluble oils showed intensified local pitting; sodium benzoate showed general over-all etching at about the same rate as in the absence of inhibition. Even at concentrations of 2% potassium dichromate offered only partial protection. These results emphasize the importance of maintaining the concentration of the inhibitors above the critical threshold values.

In the tests with copper, more than 0.1% potassium dichromate retarded corrosion; 0.25% and lower concentrations of sodium nitrite had little effect; 1.5% and more of sodium benzoate reduced corrosion, whereas 0.5% and less intensified corrosion; 1% soluble oils reduced corrosion, but lower amounts increased it. None of the inhibitors had any appreciable effect on the corrosion of tin in the presence of salt contaminant; however, the corrosion of tin was small even in the absence of any inhibitor.

In concentrations of 0.5% and higher, oil No. 1 offered some protection to cast iron in the presence of sodium chloride but increased the corrosion in distilled water; at these same concentrations, oil No. 2 gave good protection. The addition of 1% oil No. 2 completely suppressed the corrosion of both steel and cast iron in systems that were already being corroded in the absence of an inhibitor.

Corrosion inhibitors can be classified as anodic, cathodic, or adsorption inhibitors. The three salts tested were anodic types, the oils were adsorption types.—PDA. 6432

4.6.6, 7.2, 6.2.2, 8.1.4

Aerobic and Anaerobic Iron Corrosion in Water Mains. C. A. H. VON WOLZOGEN KUHR AND L. S. VAN DER VLUGT. *J. Am. Water Works Assoc.*, **45**, 33-46 (1953) Jan.

Study of principles involved and need to neutralize anodal and cathodal regions by application of internal protection. Photographs and diagrams. 28 references.—BTR. 6542

4.6.6, 7.2, 5.11

Effect of Operating Conditions on Corrosion of Hot Water Piping in Buildings. HENRY L. SHULDENER. *Corrosion*, **10**, No. 3, 85-90 (1954) Mar.

The useful life of hot water piping in building is influenced not only by the character of the water circulated, its potential corrosiveness and scale forming properties and by the piping material but also by a group of factors which may be called operating conditions.

Affecting operating conditions significantly is the design and fabrication of distribution systems.

An understanding of these factors will make improved service and longer pipe life possible.

Faulty hot water circulation creates a number of problems including fluctuating temperatures which frequently lead to overheated water and consequently to accelerated corrosion and to joint leaks caused by excessive expansion and contraction strains.

Modern hot water generation and distribution involves control devices such as aquastats and mixing valves which the building superintendent ordinarily is not sufficiently experienced with to adjust and maintain. Improper maintenance causes many pipe systems to be ruined by excessively high water temperatures. Proper design, maintenance and operation which produces an adequate supply of circulated hot water at the proper temperature not only saves wasted fuel and water but helps to prevent clogging by sediment and the products of accelerated corrosion. 6584

4.6.9, 8.4.3, 5.2.1

Here's How to Provide Cathodic Protection of Steel Vessels Exposed to Oil Field Brines. C. O. SMITH. Carter Oil Co. Paper before API, Div. of Production, Spring Mtg. of Mid-Continent District, Tulsa, March 18-20, 1953. *Oil Gas J.*, **51**, No. 51, 230+ (1953) April 27; *World Oil*, **136**, No. 6, 206+ (1953) May; *Oil World*, **46**, No. 8, 1-6, 27 (1953) April.

Cathodic protection of the interior of steel vessels handling oil-field brines reduces corrosion and operating expense. Data from experiments using small steel coupons and conducted in two types of brines produced in Central Kansas indicate that an electrical potential of approximately 1 volt between the steel vessel and a copper-copper sulfate electrode in the brine, defines protection in brines tested. Method of measuring protection effectiveness and an explanation of the variables affecting system performance and protection cost are reviewed. Table, graphs, two references.—INCO. 6519

4.6.11, 6.4.2, 2.2.7

Behaviour of Light Metal Alloys Towards Sea Water. *Aluminum* (Germany), **29**, No. 5, 203-206 (1953) May.

This reports extensive tests carried out in France at Salin-de-Giraud and Saint-Jean-de-Luz, on the behaviour of light metals towards marine atmospheres and sea water when immersed continuously or for a short time. Aluminum-magnesium and aluminum-magnesium-silicon alloys have shown good corrosion resistance after appropriate heat treatment. Aluminum of various degrees of purity and aluminum-manganese alloys are less resistant to corrosion. Aluminum-copper-magnesium and aluminum-zinc-magnesium-copper show poor resistance. Plating is recommended for the latter materials. Casting alloys show more variations than wrought alloys. Alternate immersion produces the strongest corrosion effect.—ALL. 6247

4.6.11, 7.3, 7.4.2, 5.2.3

Dow Conquers Sea Water Corrosion. D. P. THORNTON, JR. *Petroleum Processing*, **7**, No. 11, 1640-1643 (1952) Nov.

Successfully uses water from Gulf of Mexico both as coolant and to process raw material. Freeport, located on the Intracoastal Waterway, communicates with deep water in the Gulf of Mexico through a 40 ft. deep channel. Procedure for obtaining the sea water, measures to prevent corrosion, application of cathodic protection, and method of protecting condensers are described. Intermediate heads, 100 to 150 ft. of water, require cast iron casings and Monel impellers. For still higher heads, Ni-Resist or Monel casings, Monel impellers and "K" Monel shafts are used. Cathodic protection is extensively used in the water boxes of condensers at the powerhouse and throughout the process area. Photographs.—INCO. 5923

4.6.12

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Water Injection Problem. G. S. FLANDERS. Lane-Wells Co. *World Oil,* **136,** No. 1, 186-187 (1953) Jan.

Pressure differentials serve to increase the seal, corrosion can be minimized, and by using a tail pipe, salt water can be prevented from coming in direct contact with the packer seat. Problems encountered in a salt water injection project in South America are discussed, pointing out some helpful applications of inverted packers. Inverted-type packer installation in salt water injection project is shown.—INCO. 6107

4.6.2, 5.7.6

Reducing Return Line Corrosion by New Makeup Treatment. F. N. KEMMER and N. C. STRATTON. *Heating and Ventilating,* **49,** No. 11, 105-107 (1952) Nov.

A new approach to the problem of return line corrosion by reduction of makeup alkalinity through anion exchange is discussed in theory, and an example of practical application of the method is given. Illustrations and references.—INCO. 5960

4.6.2, 7.6.4

Prediction of the Appearance of Rust Damage in Warm-Water Plants. (In German). GUNTHER SEELMEYER. *Werkstoffe und Korrosion,* **3,** 211-217 (1952) May-June.

According to recent experiences, formation of internal corrosion and scaling in waterworks equipment does not depend—as generally assumed—entirely on chemical nature of the water. Effects of kind and quality of materials used and of construction and operation of the plants are also important. Attempts to clarify these factors and to give more exact definitions of the concepts of aggressive, scale-forming, and non-scale-forming waters. Tables.—BTR. 5930

4.7 Molten Metals

4.7

Corrosion of Materials by Liquid Low Melting Alloys. *Materials & Methods,* **37,** No. 3, 131 (1953) Mar.

Corrosion of ferrous, such as stainless steels, non-ferrous, such as nickel, Inconel, Monel and non-metals by sodium-potassium alloys, eutectic bismuth-lead alloy and eutectic bismuth-lead-tin alloy in a temperature range of 200-1600°F. Data are given in graph form.—INCO. 6422

4.7, 6.6.6

Effect of Molten Alumina on Alumina-Silica Refractories. K. J. BRONDYKE. *J. Am. Ceram. Soc.,* **36,** 171-174 (1953).

Penetration of commercial 9 inch brick by molten aluminum at 1400-1700°F. was studied. All SiO_2-Al_2O_3 refractories, up to 99% Al_2O_3, were penetrated, the reaction being $4Al+3SiO_2 \rightarrow 2Al_2O_3+3Si$. No relation was found between SiO_2 content and penetration, but there was a definite relation between SiO_2 content and the amount of silicon released. Penetration and release of silicon were independent of porosity, grade of refractory, or source of raw material. Conversion of SiO_2 and Al_2O_3 to mullite had no effect on penetration.—ALL. 6219

4.7, 6.6.6, 3.5.9

Corrosion of Refractories by Tin and Bismuth. T. A. COULTAS. North American Aviation, Inc., Sept. 15, 1952, 23 pp.

Static corrosion tests were made on several refractory materials in tin and bismuth at 1800°F. The materials tested in tin, listed in decreasing order of resistance to attack, were: graphite, Al_2O_3, Vycor, W. $MoSi_2$, TaC, Kennametal K-138A, Haynes Metamic LT-1, Ta, and Mo. The materials tested in bismuth, with those most resistant to attack listed first, were: graphite, Al_2O_3, ZrO_2, ThO_2, Mullite, Vycor, TaC, MgO, $MoSi_2$, Re, W, Mo, K-138A, SiC, Ta Metamic LT-1, Ir, and AISI type 303 stainless steel with Mo coating. In addition, some tests were made at higher (2600° to 3600°F.) temperatures. Results were appraised by both visual and matallographic examinations and by chemical analysis of the residual liquid metals. A small, simple method of testing materials in circulating liquids to obtain evidence of mass transfer is described. —NSA. 5953

4.8 Other

4.8, 2.3.5, 6.2.5

Studies on an Electrochemical Test of Corrosion Resistance. M. TAGAYA, M. HUJII, S. KONDO AND T. HORIBE. *J. Japan Inst. Metals,* **17,** No. 7, 342-345 (1953) July.

From the standpoint of investigating the resistance to corrosion and tarnishing in the mouth, the dental alloys in our country have been tested by dipping them in 1% lactic acid, 0.05% hydrochloric acid, 1% sodium chloride, and 0.1% sodium monosulfide solutions at 37° for 3 days. The corrosion rate of the dental chromium-nickel alloys in these acids was very low, and found to be affected or controlled by various factors. Now, by measuring the current between the specimen and $Cu/CuSO_4$-electrode immersed in the test solution, we could easily and rapidly test the corrosion properties of the dental chromium-nickel alloys, 18-8 stainless steels and vitallium alloy. The results of our experiments are as follows: The loss in weight of the dental chromium-nickel alloys in 1% lactic acid solution was compared with the amount of current measured in microamperes. The resistance of chromium-nickel alloys to lactic acid is extremely sensitive upon some unknown factors. According to the electro-chemical test, one sample of lactic acid had the property to allow the formation of protective film, another sample preventing its formation. The 18-8 stainless steels used in dentistry are perfectly passive in 1% lactic acid solution, whereas a small addition of sodium chloride changed its character. The critical concentration of sodium chloride in 1% lactic acid solution to destroy passivity are different, some samples being activated by addition of 0.5% sodium chloride solution. In fine the electrochemical test above mentioned is particularly valuable in indicating the boundary between the active and the passive states of chromium alloys—JSPS. 6580

4.8, 6.3.13

Metals and Tissue. (In German). WERNER BUFE. *Werkstoffe u. Korrosion,* **4,** No. 3, 95-99 (1953) Mar.

Discusses need for corrosion-resistant metals, suitable for use in the human body as supports for injured parts. Advantages and disadvantages of using tantalum are emphasized.—BTR. 6366

5. PREVENTIVE MEASURES

5.1 General

5.1

What's Ahead in Corrosion Prevention. H. H. UHLIG, Massachusetts Inst. of Technology. *Chem. Eng.,* **59,** No 6, 314 (1952) June.

Pore-free electro-deposited coatings, metal coatings produced by high temperature gas phase reactions, titanium clad steels, wash primers, inexpensive glass coating combined with cathodic protection for piping and tanks, increased use of corrosion inhibitors in gasoline and oil, vacuum deaeration of water and increased use of corrosion resistant alloys are predicted for the future. 6360

5.1, 5.2.1

Corrosion—An Engineering Problem. M. E. PARKER, Cormit Eng'ing Co. *Petroleum Engr.,* **25,** No. 2, D-3-D-4 (1953) Feb.

Adequately engineered installations are assured only if designed and made by properly trained persons. Certain kinds of apparatus, such as devices using the principles of cathodic protection, must be selected, installed, placed and maintained in operation by qualified engineers. Examples of misapplications of equipment are given and the danger of inadequacies is discussed.—INCO. 6622

5.1

How You Can Fight Corrosion. A. G. GRAY. *Steel,* **132,** No. 14, 102-106, 108 (1953) April 6.

Discussion on methods of preventing corrosion including metallic and organic coatings such as nickel-chromium, nickel, copper-nickel-chromium, zinc, aluminum, cadmium, chromium, copper-chromium, phosphates and resins, use of corrosion resistant metals, cathodic protection and corrosion inhibitors. Thickness of coatings, drain-off corrosion, galvanic and stray current corrosion and organic films are considered. Reference is made to the coating of steels and stainless steels. Illustrations.—INCO. 6365

5.2 Cathodic Protection

5.2.1

Temporary Ground Beds by the Roll. *Corrosion,* **10,** No. 3, 100 (1954) Mar. (A Technical Note).

Household aluminum foil, spread out on moistened ground, or preferably in water or damp ditch can be used satisfactorily as a temporary ground bed for making calculations of the current required to protect an underground installation. A 25-foot strip of aluminum will hold output constant for several hours, but for tests of 18 hours at 15 amperes or more, two 25-foot strips are recommended. Resistances as low as one-half ohm have been obtained and current output can be regulated by folding the foil back on itself. 6619

5.2.1, 8.8.1, 7.6.1

Cathodic Protection Can Save Chemical Process Equipment. L. P. SUDRABIN. *Chem. Eng.,* **60,** No. 5, 196-200 (1953) May.

Nature of cathodic protection; anode

selection (platinum, aluminum, magnesium, graphite); applications to buried pipelines and tanks; hot water pipes; clarification equipment; marine applications. 12 references.—BNF. 6640

5.2.1, 8.9.3, 7.2, 4.5.1

Cathodic Protection and High Resistivity Soil. H. C. VAN NOUHUYS. *Corrosion*, **9**, No. 12, 448-459 (1953) Dec.

A two-part report of Southeastern Pipe Line's cathodic protection system. Part One deals with a 25-rectifier system from Port St. Joe, Florida to Atlanta, Georgia, which lowers the pipe-to-soil potential a minimum of .3 volt based on the remote electrode criterion. The pipe line consists of 320 miles of bare and 40 miles of coated 8-inch products line. Design, installation and economic aspects of cathodic protection in the ultra-high resistivity soils encountered are presented.

Part 2 is a condensed description of a comparative test between magnesium anodes and rectifiers in the somewhat lower—though still very high resistivity soils between Atlanta and Chattanooga. Magnesium ribbon was installed and potential tests were made every 25 feet on the four test sections of pipe. The cost of annually checking the installation to determine if it is operating properly was considered to outweigh its near-ideal distribution characteristic. 6529

5.2.1, 8.9.3

New Cathodic Method. P. REED. *Oil Gas J.*, 51, No. 45, 30 (1953) Mar. 16.

In applying cathodic protection to a reasonably well coated line, it was recommended at the Fourth Annual Tulsa Short Course for Pipeliners, sponsored by the Tulsa section of the NACE, that the installation of anodes be done in two stages. Half of the estimated anodes should be installed and allowed to function for several weeks or months before making a pipe-to-soil survey to determine the location of the other half. There is a tendency for the output of the anodes to equalize in time. 6547

5.2.1, 8.9.3, 2.4.3

Cathodic Protection Monitor. M. E. PARKER. *Oil Gas J.*, **52**, No. 1, 143 (1953) May 11.

Permanent installation for monitoring pipe-line cathodic protection system is suggested. The desired quantity (pipe-to-soil potential) is read with an ordinary panel-mounted voltmeter. Plotting values graphically will yield valuable information about coating deterioration, polarization, variation of current output with soil moisture conditions and other changes whose effects are too slow for direct observation. Diagram.—INCO. 6440

5.2.1, 2.2.8

Value of Test Coupons in Cathodic Protection. M. E. PARKER. *Oil Gas J.*, **52**, No. 1, 126-127 (1953) May 11.

Test coupons may be used to answer two questions. Is full protection being afforded at a certain point on a structure? What is the current density at a given location?—INCO. 6442

5.2.1

Anode-Bed Inspection and Maintenance. M. E. PARKER. *Oil Gas J.*, **52**, No. 9, 113 (1953) July 6.

Periodic inspection of an installed cathodic protection system may at some time disclose a decrease in the current output, as being responsible for a total or partial loss of protection. This can happen either to rectifier systems or to those using magnesium anodes and part of the technique for locating the trouble is applicable to either type. Methods for checking anodes and for locating inactive anodes are given.—INCO. 6443

5.2.2, 4.6.11, 8.9.5

How to Control Marine Corrosion With Galvanic Anodes. R. D. TAYLOR. *Marine Eng.*, **58**, No. 6, 69, 73 (1953) June.

Magnesium galvanic anodes are used for the protection of water, oil and gas pipe lines, storage tanks, ballast compartments in tankers, tank barges and cargo ships, steel piers and piling, offshore drilling platforms, and the underwater hull surfaces of active and laid-up vessels. A properly designed cathodic protection system will provide current to offset corrosion on bare surfaces. The effectiveness of such a system can be determined readily by visual inspection and can be confirmed by electrical measurement. The first result is a descaling of the bare steel being protected. It begins immediately and continues until virtually all scale has been loosened. The second result is the laying down of a white or tan colored calcareous deposit when protection is being afforded. This is first noted in areas adjacent the anodes but spreads out as these local areas become polarized and require less current. The same effects can be noted on the exterior under-water hull surfaces. Magnesium anodes have a cast-in steel core by which they are fastened to the structure to be protected either through welding, bolting or the use of a connecting wire. In ballast tank applications, anodes with cast-in steel hangers are used so that when installed, the anodes will stand off from the surface to be protected. On exterior hull surfaces, the anodes of necessity must be fastened directly to the structure of the ship. An insulating blanket of asphaltum, rubber or other material is installed between the anode and the hull surface to reduce the local action immediately adjacent the anodes. Installations of magnesium anodes on ballast compartments are designed to give an added life of two to three years, while on a vessel hull a life of one to two years can be expected. Overprotection can cause blistering or stripping of some paints adjacent the anodes, but even when this occurs cathodic protection is afforded to those areas so no damage is done by corrosion. Properly applied vinyls are very resistant to such blistering.—ALL. 6587

5.2.3, 7.7, 3.6.9

Magnetic Amplifier Controls for Rectifier Protecting Underground Metallic Structures Cathodically. OLIVER HENDERSON. *Corrosion*, **9**, No. 7, 216-220 (1953) July.

This paper covers the initial attempt on the part of the Ohio Bell Telephone Company to use a magnetic amplifier to give continuous control of the output of a copper-oxide rectifier used for cathodic protection of underground lead covered cables. The controlled rectifier was designed for use at a location where stray current "end effects" were damaging underground telephone cables and municipal light cables and were threatening high-pressure water mains. When properly adjusted, the output of the rectifier will increase or decrease automatically so that at each instant the amount of forced drainage will be adequate to protect the underground telephone cable sheath but will not be in excess of the value at which neighboring underground matallic structures would become anodic and would thus become subject to corrosion. For satisfactory operation the amplifier had to be designed to give a large gain so that a change in the control voltage of only .2 volt (+.1 to —.1 volt) would be sufficient to vary the output of the rectifier from practically zero current to full rating. In the installation described in this paper the gain of the magnetic amplifier is in the order of 12,000. The magnetic amplifier type of control is well suited to outdoor installations subject to wide changes in temperature and at remote locations where frequent maintenance inspections are not feasible. The magnetic amplifier has advantages over other available control devices which accomplish this same purpose in that it has no moving parts, no vacuum tubes, batteries, motors, relays or contactors. The magnetic amplifier gives a continuous output control which is superior to the stepped increment changes that result from relay or contactor operation. 6083

5.2.3, 7.7, 4.5.1

Cable System Design for Cathodic Protection Rectifiers. RAY M. WAINWRIGHT. *Corrosion*, **9**, No. 9, 325-328 (1953) Sept.

The design of any current-carrying cable system involves certain basic factors, which may be listed briefly as follows: 1. Ability to meet mechanical

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stresses and other environmental requirements; 2. Ability to meet voltage attenuation limits; 3. Ability of the insulation to withstand applied voltages; 4. Ability to meet limitations on current due to temperature and insulation stability; 5. Conformance to Kelvin's Economic Law; 6. Conformance to legal codes, safety rules, and similar requirements. The importance of each of these factors is discussed in the light of cathodic protection requirements and installations. Emphasis is placed on cable systems which connect the direct current output terminals of the rectifier to ground beds and to the protected metal structures. Frequently engineers disregard one or more of the six factors in designing cathodic protection cable connections. For example, the tendency is to design to fit the current-carrying capacity of cables as set forth in the various handbooks and to neglect a consideration of Kelvin's Law, which shows that the choice should be toward much larger cables and lower current densities. Also because cables buried underground are subject to concentrated electrochemical attack the type of insulation is important. Ordinary insulations may not be sufficient and normal voltage ratings may be unimportant.

A method of determining annual fixed costs of cables is outlined and charts are given which enable the engineer to balance fixed charges against cost of losses and thus select the optimum cable size based on economy. Consideration also is given to the effect on the economic picture of selecting cable sizes somewhat off of the theoretical optimum. 6163

5.2.3, 8.9.5, 2.2.7, 4.6.11

Cathodic Protection of Active Ships in Sea Water With Graphite Anodes. K. N. BARNARD, G. L. CHRISTIE and J. H. GREENBLATT. *Corrosion,* **9,** No. 8, 246-250 (1953) Aug.

Trials on three steel tugs with impressed current cathodic protection systems using graphite anodes are described. The trial results indicate that operation of a graphite anode impressed current cathodic protection system, at reasonable current outputs, requires shielding of the hull around the anodes to obtain uniform current spread at low currents. Paint films have not been found satisfactory as they break down under the relatively high voltage drop (5.5 volts) occurring with graphite anodes. Satisfactory shielding was obtained with vulcanized rubber and results indicate that flame sprayed polymers also may be satisfactory. 6108

5.3 Metallic Coatings

5.3.2, 5.3.4

Heavy Rhodium Electroplates Now Possible. ALFRED M. WEISBERG. *Materials & Methods,* **37,** 85-87 (1953) Mar.

Shows that rhodium can be deposited on most common metals and provides excellent corrosion and water resistance. —BTR. 6602

5.3.2, 4.5.1, 3.8.3

Galvanized Steel Pipe Resists Soil Corrosion. *Materials and Methods,* **37,** No. 3, 180-182 (1953) March.

A recent study by the National Bureau of Standards shows that galvanized steel having 3 ounces of zinc per sq. ft. of exposed surface is very resistant to corrosion in many soils which are highly corrosive to bare steel. The galvanized specimens continue to show high corrosion resistance in most soils after the outer zinc coating and even the zinc-iron alloy layer has entirely corroded away. It is suggested that this continuing protection may be due to an inorganic coating, probably silicious, previously formed by galvanic action between the outer zinc coating and the underlying steel or alloy layer.—ZDA. 6474

5.3.2, 4.2.4, 8.1.2

Steel Protection by Sprayed Aluminium. *Engineering,* **175,** No. 4540, 158 (1953).

A brief report on the corrosion resistance exhibited by an aluminum sprayed steel building erected in 1937, in a highly corrosive steel works atmosphere. Signs of rusting are now apparent and 15 years is thought to be the maximum life that can be reasonably expected from the coating under these particular conditions.—MA. 6467

5.3.2, 8.8.1, 8.3.5, 7.5.2

Stainless Steel Spraying of Drums and Shafts in the Chemical and Food Industries. *Electroplating and Metal Spraying,* 6, No. 7, 267, 269-271 (1953) July.

In the chemical and food industries, the spraying of stainless steel is performing valuable service in enabling shafts and larger cylindrical objects of various kinds to withstand corrosive and abrasive conditions. Spraying of a margarine freezing drum with 18-8 is illustrated.—INCO. 6399

5.3.2, 7.2, 8.9.1

A Coating Alloy for High-Temperature Use: (C.26 Alloy). *Engineer,* **195,** No. 5065, 274 (1953) Feb. 20; *Engineering,* **175,** 248 (1953) Feb. 20.

Rolls-Royce, Ltd. developed a new coating alloy which is being used regularly on valves in civil aircraft engines. Use of a coating of this alloy on valve head and seating has increased period between scheduled valve overhauls to 1000 hours and even after this time, only a small proportion of valves are withdrawn from service. Manufacturing and marketing rights have now been acquired by Deloro Stellite, Ltd. C.26 alloy has a nickel base and contains chromium, aluminum, molybdenum and other minor additions. Alloy is non-brittle and does not crack radially under/time temperature stresses imposed by highpowered engines. It is used on inlet valves owing to abrasion-resisting properties in contact with product of combustion of leaded fuel. Good wearing characteristics result in very low loss of tappet clearances. It resists oxidation at all temperatures up to 1250°C. Provided that iron content of alloy is kept below 1%, alloy is highly resistant to lead oxide and lead oxybromide at temperatures up to 800°C. It resists molten caustic soda and was used in form of cast containers for fluxes containing fluorides. Physical, electrical, mechanical and corrosion-fatigue properties are described. It is deposited by means of oxyacetylene torch; arc-melting is used where iron content not critical. Casting is carried out by normal commercial methods.—INCO. 6391

5.3.2, 4.5.1, 2.2.6

Underground Corrosion of Galvanized Steel. *Oil Gas J.,* **51,** No. 51, 289 (1953) April 27.

Galvanized steel having 3 oz. zinc per square foot of exposed surface is highly resistant to corrosion in many soils which are very corrosive to bare steel. This was confirmed in tests conducted on short lengths of both galvanized and uncoated steel pipe, and zinc plates, which were buried at 15 test sites representing a wide range of soil properties for periods up to 13 years. Illustrations. —INCO. 6388

5.3.2

A Critical Look at White Brass Plated Coatings. R. B. SALTONSTALL. *Materials and Methods,* **27,** No. 2, 97 (1953) Feb.

Bright white brass plating (75-90% zinc) is not considered suitable for outdoor exposure unless it is protected by a durable clear synthetic coating. Such coatings are generally incompatible with chromium plated white brass, because stoving accelerates stress-cracking in the deposit. However, chromium over white brass is reasonably satisfactory for interior goods not exposed to moisture, high humidity or corrosive vapors. White brass is said to have shown advantages over bright nickel in plating zinc alloy die cast toy pistols, where the unprotected inner surfaces led to contamination of the bright nickel solution. —ZDA. 6480

5.3.2

Modified Bronze Plating as a Substitute for Nickel. G. SCHMERLING. Silvercrown Ltd., London. *Electroplating,* **5,** 115-118 (1952) April.

A newly developed bronze plating process, Nickelex, appears to be the first satisfactory alternate for nickel plating. The plating, a true copper-tin alloy, is pore-free and has a hardness comparable to that of nickel, viz., 250-350 Vickers. It is suitable both as an independent finish which can be polished to a high finish luster and as an undercoating for bright chrome. It is more corrosion resistant than copper, brass, copper-chrome (with or without lacquer), and possibly nickel-chrome. Deposits of 0.001-in. Nickelex bronze and 0.00002-in. chrome on steel have not only passed the 100-hour salt spray test but have lasted 250 hours in the salt-spray cabinet, compared to 150 hours for a coating of 0.0005-in. copper, 0.0005-in. nickel, and 0.00002-in. chrome.

Nickelex bronze can be deposited directly not only on steel and cast iron, brass and other copper alloys, but also on zinc die castings. It is also suitable for plating aluminum, following the usual zincate dip and low pH copper pretreatment. Nickelex plating lends itself to the usual coloring methods; thus, a jet-black finish can be obtained by subjecting the coating to a short anodic treatment in an alkaline solution. This finish is hard and abrasion resistant and needs no lacquer coating.

Nickel plating equipment can be readily converted to the Nickelex plating process. The plating solution is of the cyanide type and can be used in ordinary mild steel or rubber-lined tanks. The temperature for plating is 150°F., the rate of deposition is 0.002-0.003 in. per hour depending on current density, and a plating time of about 30 minutes is adequate for most purposes. A minimum of laboratory control is necessary. Special bronze anodes in single circuit are used. —PDA. 5921

5.3.2, 5.3.4, 3.5.9

High Temperature Oxidation Prevented by Sprayed Aluminum. *Electroplating and Metal Spraying,* **6,** No. 2, 74 (1953) Feb.

Sprayed aluminum and the aluminizing process are frequently used for protection of steel and sometimes other metals, against high temperature oxidation. The process forms a thin, impervious film of aluminum oxide, which is highly refractory and self-healing up to 470°C. For service at higher temperatures, it has to be alloyed with steel, by either 1. heating the sprayed article for 10 to 30 minutes in a furnace at 800°C., having first protected the coating with bitumastic paint; 2. using aluminum wire contining 0.75% cadmium for spraying followed by furnacing. The cadmium functions as a deoxidizer and reduces surface tension during melting; or 3. spraying with unalloyed aluminum and doping with ethyl silicate. The alloy formation takes place automatically during the first hours of service. In aluminizing, thickness of the sprayed aluminum layer should be from 0.006 to 0.008 inch for if the coat is too thick, cracking results.—ALL. 6112

5.3.2, 6.3.14, 1.6

Symposium on Tin. (Book Paper cover Books.) **1953, 111 pp. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.**

This booklet consists of seven items, six papers presented at the 55th Annual Meeting of ASTM at New York in June, 1952, and one item a panel discussion "The Analysis of Tin." As is pointed out by Frederick A. Lowenheim in one of the papers "The Production and Uses of Tin Coatings," corrosion resistance or protection is seldom the primary reason for the choice of tin as a coating. The various characteristics of tin, its numerous uses, methods by which it is applied, reasons for its use, effect of impurities (82 references) determination of impurities, and other facts are enumerated. 6242

5.3.4, 6.2.2

Corrosion-Resistant Iron-Base Metal Powder Products. N. I. MOSKVIN. *Vestnik Mashinostroeniya,* **32,** No. 3, 73-76 (1952).

Study of production and properties of corrosion-resisting iron-powder parts to be used chiefly as sealing elements exposed to corrosive media or to high temperatures. Particulars on simultaneous sintering and chromizing of iron-powder compacts. Conditions of chromizing selected; three methods of chromizing used. Data on microstructure, hardness, corrosion resistance, and chromized-layer thickness of specimens. Manufacture of trial lot of sealing rings for valves, chromized and infiltrated with phenol-formaldehyde resin, and preliminary data on performance of rings. Translation available: Henry Brutcher, Box 157, Altadena, Calif. 5959

5.3.4, 7.8

Hot Dip Aluminizing Affords Protective Surface. J. B. RUSSELL. *Steel,* **131,** No. 2, 100, 102 (1952) July 14.

A continuous process for coating steel strip or wire is described in which the metal passes through the following steps: 1. Bluing furnace at a temperature of 800-900°F., which serves to degrease the strip and remove all volatile material. 2. Hot muriatic pickling bath. 3. Cold water rinse, hot water rinse, and scrubbing unit. 4. Hot air dryer. 5. Preheat furnace which heats the steel to 1300 or 1350°F. and operates under a positive atmosphere of forming gas which is essentially 90 percent nitrogen and 10 percent hydrogen. 6. Air-tight turndown chute into the coating bath. 7. Out on the vertical through a cooling tower and then through a roller leveller and upcoiler. A submerged electrode salt furnace may be used for holding the aluminum bath. A salt having a higher density than aluminum is used, and the aluminum floats on top of it. The salt is heated by resistance of electrical current between the submerged electrodes. The aluminum is heated directly by radiation and conduction from the molten salt. In general, the aluminum-beryllium-silicon coatings possess the most favorable combination of properties from the standpoint of color, surface texture, ductility, and ease of coating.—ALL. 5929

5.3.4, 3.5.9

Uses of Sprayed Metal Coatings. *Product Finishing,* **6,** No. 5, 68-76 (1953) May.

The article refers particularly to sprayed metal coatings of zinc and aluminum on steel and the use of wire, powder and molten metal pistols for metal spraying is described. The purposes for which the coatings have been used, both with and without the addition of paint coatings and the main benefits of corrosion resistance and high temperature oxidation resistance that may be obtained are surveyed.—ZDA. 6505

5.3.4

Liquid Blanket Reduces Oxidation of Molten Zinc. A. A. PATERSON. *Steel,* **132,** 136, 138 (1953) April 13.

Shows that regenerative crystals added to galvanizing bath serve to maintain fluidity of blanket which in turn effects sharp reduction of dross formation.—BTR. 6437

5.4 Non-Metallic Coatings and Paints

5.4.2

New Corrosion Proof Surfacing Material. *Wire and Wire Products,* **28,** No. 1, 72 (1953) Jan.

Ceilcrete is a combination of synthetic liquid resin, inert fillers and pigments and cures into a hard dense stonelike corrosion proof surface. It is used on walls and floors subjected to corrosive liquids or atmosphere. It resists solvents, acids and alkalis, and is nonsparking, non-slip and has high impact strength with remarkable abrasion resistance. Manufactured by Ceilcote Co. —INCO. 6137

5.4.2, 2.4.2, 7.6.1

The Chemical Resistance of Glass Fused to Steel. E. A. SANFORD AND O. J. BRITTON. Pfaudler Co. Am. Soc. Testing Materials, Preprint No. 92a, 1953, 6 pp.

Glassed steel, or glass fused to steel is often used for process equipment because of its wide range of chemical resistance. A tabulation of test results on the chemical resistance of glassed steel includes data and information on hydrochloric acid, nitric acid, sulfuric acid and phosphoric acid at temperatures above 212°F. Specific instances where glassed

CLEANING, COATING, WRAPPING & RECONDITIONING

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HOT DOPE

Straight from the Kettle on PIPE PROTECTION

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By Boyd Mayes

• Some feller with a big load of 4" broke down his long haul truck outside our establishment and we went out to see while he was waiting for help. We got to talking and it seems he was from the Piney Woods too, so we found one thing real good in common. He went on telling me the woes of long hauling and how he hated it and contractors too. Finally, I got around to asking him how long he had been at it and he said 15 years. "That's funny" I says: "If you hate it so how come you keep at it?" He puzzled a minute and then said: "Well, you know there's lots of things I hate worse." All of which goes to show how hard it is to find a man who don't like to talk. Now me, I like contracting—cause everyone I meet is my friend—some are old and some new—some are little in business, some are big . . . but they're all BIG to me. Sometimes they help me—maybe I help them. We all get along pretty well working . . . that's about all all of us do . . . work. Seems that it's not so much the money as the job we're in together—a job well done with friends. Guess that's what they mean when they say—every call a pleasure. Yes, I like the contracting business. Seems every day we meet up with old friends—new friends—old timers—new ideas—tried ideas—even some untried—but they all make the day interesting. It's been like that for 26 years—that's our record for working at the main job we know—coating, wrapping and reconditioning pipe. We're proud to offer the best of men and equipment to serve you.

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steel is being used in severe services are cited. A novel design laboratory test unit for glassed steel but adaptable to other coatings is described and other methods and equipment for laboratory and field tests are given. Reference is made to an acid-resistant glass with improved alkali resistance which was thoroughly field tested and is now in production. Illustration, table.—INCO. 6634

5.4.5, 4.6.11, 6.6.11

Protect (Boats Against Fouling) with (a) Single Coat of Fast-Drying Paint. *Science News Letter,* **63,** No. 4, 53 (1953).

A fast-drying, single coat of a vinyl resin based paint containing cuprous oxide in excess of the normal quantity has in some cases repelled marine growth on wooden boats for 18 months.—RPI. 6501

5.4.5, 2.2.5

Paint vs. Corrosion—Some Aspects of the Problem in the Gulf Coast Area. V. B. VOLKENING. *Corrosion,* **10,** No. 2, 63-69 (1954) Feb.

After briefly mentioning the theory of metallic corrosion the author relates the problems encountered by Dow in protecting its Gulf Coast plants against atmospheric corrosion. Examples of coating successes and failures are given. The method which Dow uses of testing paint cooperatively with the manufacturer is explained. The author points to advantages of proper surface preparation and suggests too little attention is paid to educating the 350,000 painters who apply coatings to metals in proper application techniques and that paint manufacturers, paint manufacturers' associations and the National Association of Corrosion Engineers might find the organization of schools for painters a worthwhile activity. 6552

5.4.5, 5.4.3, 4.5.1, 8.9.5

The Use of Organic Protective Coatings in Controlling Corrosion. EDWARD G. BOBALEK. *Corrosion,* **10,** No. 2, 73-81 (1954) Feb.

The principles applying to the formulation of organic coatings are given and the effects of vehicle, pigments and thinners are discussed. Special problems applicable to the preparation and application of plastic coatings are discussed with particular reference to their adhesion, solubility and pigment dispersion characteristics. Plastic prefabricated liners, liquid coatings, dispersion resins, hot melt techniques and mastics are covered. The mechanisms by which coatings retard corrosion are listed and the relative value of barrier and polarizing coatings mentioned. Coatings suitable for severely corrosive environments are considered and the special qualities of coatings suitable for use underground are listed. The questions of adhesion, permeability, surface preparation and chemical stability are correlated for coatings suitable for underground pipe or marine vessels. 6551

5.4.5

Evaluation and Uses of Amine Resins. F. SCHOLLICK. *Paint, Oil, Color J.,* **123,** No. 2832, 224, 227 (1953).

Butylated urea resins have the widest application in paints. In blends with alkyds it is essential to have sufficient primary alcohol present to maintain stability. Such blends are cold-curing in presence of acids. Alkyd/amine resin/NC blends are popular for stoving finishes. Adhesion of films from amine resin/epoxide resin lacquers is high and if the epoxide resin is esterified, the chemical resistance is also high.—RPI. 6499

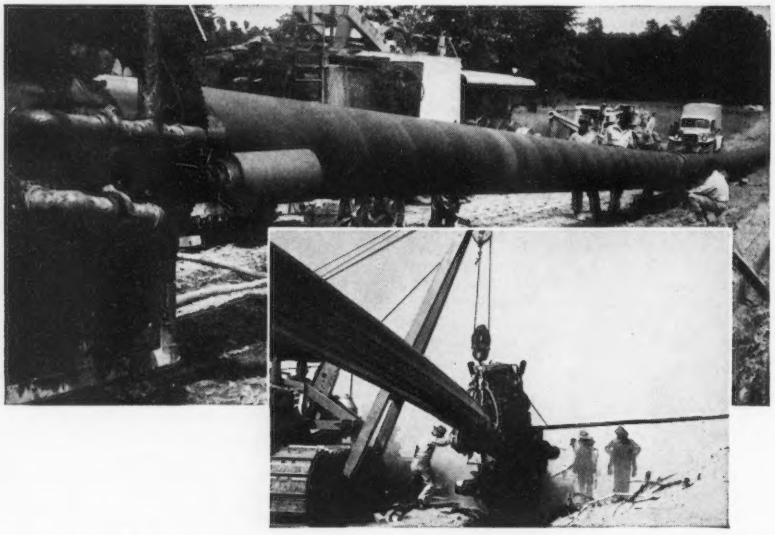
5.4.5

Observations on the Chemical Action of Primers and Anti-Rust Media. BERNHARD F. H. SCHEIFELE. *Werkstoffe u. Korrosion,* **4,** No. 6, 208-209 (1953) June.

Active primers having an acid content react with metals and form an insoluble complex metallic salt-pigment-resin combination. With the exception of polyvinyl-butyrate, all forms of binders, including other compound polymers and artificial resins, are employed. Generally speaking, phosphoric acid is employed as the reactive component, while zinc chromate is used as the anti-corrosive pigment. An addition of lamellar paints (aluminum-powder, mica or talcum) improves the adhesive powers and the impermeability of the protective film. The active primers are thinly applied and under strongly corrosive conditions, an additional coat of some anti-corrosive paint is necessary. Such primers form an anti-corrosive film on iron, aluminum, light metals and galvanized iron, as well as strongly adhesive foundations for successive coats of colored paint.—ALL. 6488

5.4.5, 2.2.5, 1.7.1

Thirty Years' Experience in Testing



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Aluminum Paint Performance. ROBERT I. WRAY. *Corrosion*, **10**, No. 2, 50-58 (1954) Feb.

Descriptions and illustrations are given of the results achieved with coatings of various kinds, including different formulations of aluminum paint on steel and aluminum bases at the Aluminum Laboratories' several testing stations. Advantages of proper surface preparation and application techniques are demonstrated by improved service life in both long and short time tests. Tests show relative merits of various primers and of aluminum paint as an intermediate coat. Methods of testing employed at Aluminum Laboratories are described and illustrated. 6484

5.4.5

Report of Investigation on Protective Coating for Metal Accessories Used in Marine Corps Pyramidal Tents. NORMAN SACHS. U. S. Marine Corps Depot of Supplies, Philadelphia, Report No. 05, Feb., 1952. 35 pp.

The results of 2-yr. laboratory and service testing demonstrated that the deterioration of zinc-dipped metal plate and chain assemblies and similar galvanized metal accessories for pyramidal tents can best be prevented by applying first a coat of BuShips No. 117 wash primer, followed by a top coat of Marine Corps Formula No. 1, a vinyl alkyd composition. This coating system is much more effective and economical than cadmium or chrome plating or conventional organic coatings. It can be substituted for the conventional, unsatisfactory bronze finish on brass grommets, and also for the black-oxide finish on zinc grommets. The coating system has no deleterious effects when accidentally applied to small areas of tent duck and confers increased protection against weathering. The satisfactory results obtained with this metal treatment on over 10,000 pyramidal tent chains suggest its application to steel structure such as bridges, fences, and tank supports. The pretreatment wash primer, BuShips Formula No. 117, comprises 80 volumes resin component and 20 volumes acid component. The resin component comprises, in lb. per 100 gal. of final mixture: 56 polyvinyl-butyral resin (18-20% vinyl alcohol and maximum 1% vinyl acetate); 54 insoluble zinc chromate; 8 magnesium silicate; 0.6 lampblack; 125 n-butanol; and 380 ethanol. The acid component consists of, in lb. per 100 gal. of final formulation: 28 phosphoric acid; 25 water; and 102 ethanol. Marine Corps Coating Formula No. 1 has the following composition, in lb. per 100 gal.: 70 dry, green chromium oxide; 3 lampblack; 80 magnesium silicate; 195 long-oil, soya-modified alkyd resin (24% phthalic anhydride); 75 vinyl resin (89.5-91.5% vinyl chloride, 5.3-7.0% vinyl alcohol, and 2-5% vinyl acetate); 400 isobutyl methyl ketone; 40 xylene; 0.2 lead naphthenate drier; and 0.1 each of cobalt and manganese naphthenate driers. 5866

5.4.5

Protective Coating. *World Oil*, **136**, No. 1, 80 (1953) Jan.

Flexcoat was developed to give protection against corrosion caused by atmospheric conditions, vapors, fumes, spillage and chemical splash. It protects against corrosion by acids and alkalis and can be brushed, sprayed or dipped,

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or applied over old paint. It is made in a wide range of colors to decorate and identify machines and pipe lines. A plastic resin finish, it contains no oxidizing oils or resins. Manufactured by Flexrock Co.—INCO. 6142

5.4.5

Cold-Dip Plastic Coating Simplifies Corrosion Protection. *Iron Age,* **171,** No. 5, 117 (1953) Jan. 29.

Cold-dip coatings are a specially formulated plastisol composition. The plastisol is a fluid disperson of a vinyl resin in plasticizers to which stabilizers, rust inhibitors, colors and fillers have been added; it is also used as a vehicle to carry special corrosion inhibitors. Plastisols are readily converted into tough coatings by heating them to 300°F. Almost any item which can be mounted or immersed can be dip coated. Manufactured by R. M. Hollingshead.—INCO. 6118

5.4.5, 6.6.8

The Corrosion Engineer Uses Plastics. FRANK L. WHITNEY, JR. *Corrosion,* **9,** No. 4, 123-131 (1953) April.

Continued progress in the development and improvements in the properties of plastics places these materials high on the materials of construction lists for the corrosion engineer to consider. To achieve maximum performance and economy in their use—what they are, what their chemical and physical limitations are and how they are best applied and installed must be known. An attempt is made to simplify the task of acquiring general knowledge of the plastics by dividing into three major groups and thirteen "families." Factors to be considered in order to obtain good performance are presented. These include effect of composition, when to use thick and thin films, importance of surface preparation, testing procedures and design and economics. The effects of polymerization, the use of modifiers, plasticizers, pigments and binders are briefly discussed in relation to corrosion resistance and physical properties. Some "do's and don'ts" on the use of thin and thick films are outlined and illustrated. If more adequate testing procedures are employed, considerable time and money can be saved; a brief outline of some of the more important features are mentioned. Design is important to good performance, whether the plastic is used as a coating, a lining, or a solid installation. 6140

5.4.5, 7.10

New York City Protects Its Mail Boxes with Bright Aluminum Paint. *Am. Metal Market,* **60,** No. 45, 9 (1953) March 7.

Aluminum pigments will be used by New York Post Office for painting its 4,400 drop boxes in Manhattan and the Bronx. Experiments conducted on 40 newly installed boxes attached to aluminum lamp posts along Park Avenue proved that the boxes protected by aluminum paint were less susceptible to rust, and easier to see in gloomy weather and at night. It is estimated that these boxes will only require paint every one to three years.—ALL. 6230

5.4.6, 1.7.1

Shop, Field, and Maintenance Painting. Paint Application Specifications. No. 1: 1953, 16 pp. Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, 13, Pennsylvania.

One of the series of paint application specifications issued by the council. The specification is expected to apply to the painting of interior and exterior steel surfaces of structures exposed to weather, moisture, condensation or other corrosive conditions. The specifications include procedures applicable when conditions are sufficiently corrosive to warrant the best application. Definitions, procedures, storage of paints and thinners, temperature recommendations, kind of brushes to be used, brushing technique, spray equipment and application technique, shop, maintenance and field painting, descriptions of different classes of paints, drying times and safety precautions are covered.

5.4.7, 6.2.3, 6.6.5

Painting the Steel Reinforcement in Reinforced Concrete. H. RABATE. *Trav. Peinture,* **7,** No. 4, 95-97 (1952).

The steel reinforcement will rust only if cracks appear in the structure; rusting may be accelerated in the presence of the salts used to confer cold-resistance to the concrete. Paint systems suggested include red-lead-pigmented alkyds followed by a tar paint, or a red-lead pigmented phenolic followed by a styrene or vinyl polymer coating, or a chlorinated rubber system.—RPI. 5963

5.4.7, 5.4.2

Processes. *Product Eng.,* **24,** No. 7, 9 (1953) July.

New technique under development uses a flame-spray hand gun which shoots porcelain material through an acetylene torch and fuses it to steel. Its portability allows porcelain to be sprayed on structures too large physically for factory treatment. Developed by Seaporcel Metal Inc.—INCO. 6462

5.4.7

Preventing Metallic Corrosion by Modern Painting Techniques. H. W. RUDD. *Paint Manuf.,* **23;** Nos. 2 & 3; 41-44, 63; 77-80, 93 (1953) Feb., March.

After discussing the removal of mill scale from steel, the author describes etch primers, pigmented with zinc tetroxychromate and zinc-rich primers. The etch primers appear to adhere well to steel because the surface is etched by the phosphoric acid present. It is suggested that their successful use on aluminum may have a different basis. The behavior of zinc-rich paints is described at length, with emphasis on their value as under-water paints, especially when they are themselves protected by sealing coats. Necessity of using media of low water permeability for top coats and employment of cathodic protection methods in conjunction with paint systems are discussed. 17 references.—BTR. 6571

5.4.10, 7.7, 6.3.8, 5.2.1, 4.5.1

Cable Sheath Corrosion and Prevention. R. B. REINITZ. *Corrosion,* **9,** No. 11, 425-431 (1953) Nov.

Two-thirds of cable failures are attributable to corrosion and mechanical damage. Replacement costs and service interruptions are considerations of prime importance. Conservation of limited metal resources is an additional reason for seeking improved methods of preventing corrosion.

While stray current corrosion has decreased in recent years, galvanic and concentration cell corrosion have multiplied. Also, other causes of corrosion, such as microbiological action, scoring, de-icing by means of salts, electro-endosmosis, cement arc proofing and alternating current are receiving increased attention.

Cathodic protection, when used for cable sheathing, serves primarily as a means for mitigating rather than completely eliminating corrosion and its applications are limited. On the other hand, a suitable covering over the lead sheath offers a dependable and more certain method of protection for underground cables.

Nearly twenty years of service experience without a recorded case of sheath corrosion have established the value of a thermosetting covering having a fiber-free, homogeneous wall of properly compounded neoprene. Recently adopted manufacturing methods have led to an improved covering, possessing a more uniform wall thickness, greater density and freedom from laminations. 6591

5.4.10, 8.9.3

Protective Coatings for Buried Pipelines. K. A. SPENCER AND H. B. FOOTNER. Paper before Soc. Chem. Industry, Chem, Eng'g. Group, the Newcastle Section & Corrosion Group, Newcastle, Feb. 18, 1953. *Chemistry and Industry,* No. 19, 448-455 (1953) May 9; Disc., No. 23, 568 (1953) June 6.

Recent developments in the coating of buried and submerged pipelines by coal tar base and petroleum bitumen base enamels. Properties, selection of coating materials, wrapping materials, preparation of the metal for coating primers for coating materials, hot enameling, enamel melters and melting operations, rolling rig type coating and wrapping equipment, line traveling equipment and testing of coatings are discussed. The continued use of coal tar pitch base and petroleum bitumen base coatings is economically supported by the development of cathodic protection as a second line of defense against corrosion. Illustrations, 6 references.—INCO. 6515

5.5 Oil and Grease Coatings

5.5.2

Preparation and Properties of Greases. Papers before Nat. Lubricating Grease Inst., Ann. Mtg., Chicago, 1952. *Oil Gas J.,* **51,** No. 35, 54-56, 58, 61 (1953) Jan. 5.

Papers include: "Additives for Greases," R. T. Macdonald and J. L. Dreher; "Silica Aerogel-Thickened Greases," E. C. Milberger and L. J. Swatik; "A Continuous Method for Manufacture of Lithium Grease," P. J. Baker and N. T. Joyner; "Performance of Synthetic Greases," E. R. Booser, A. E. Baker and E. G. Jackson. Rust preventives, extreme-pressure agents, oxidation inhibitors, and stringiness agents are among the additives used. Laboratory tests and field performance indicate future importance and utility of silica greases. Slurry preparation and heating, blending temperature, and chilling below the critical milling temperature are some of the steps in continuous manufacture of lithium grease. Silicones, diesters, and polyethylene glycol-base greases are used under conditons where petroleum lubricants are not suitable. Illustrations. —INCO. 6159

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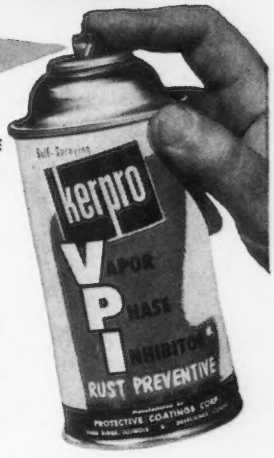

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5.5.3

Corrosion Proofing. *Rev. Sci. Instruments,* **24,** No. 1, 90 (1953) Jan.

No-Rust FPR, a petroleum base liquid developed for application to freshly machined metal surfaces where finish and tolerance must be protected against the corrosive action of perspiration during handling operations. It may be applied on brass, cadmium, copper, magnesium, steel, and zinc by dipping, spraying or flooding. The liquid displaces a water film by preferential wetting, and removes cutting or grinding compounds as well as perspiration residues. It leaves a thin colorless protective film which can be removed by a petroleum solvent when the part is to be used. Manufactured by Gulf Oil Co.—INCO. 6139

5.5.3

New Liquid Stops Corrosion. *Metal Finishing,* **50,** No. 9, 100-101 (1952) Sept.

Protection of mild steel from corrosion after cleaning is achieved by the application of Kelite M-2. It is claimed to be superior to petroleum oil used for the same purpose since it affords corrosion inhibiting properties and eliminates the need for drying prior to treatment. May be applied by immersion, spray or brush.—INCO. 5968

5.5.3

Dewatering Fluids. *Product Finishing,* **5,** 80-89 (1952) Oct.

Describes and illustrates experiments to show merits of above for preventing corrosion by removal of water from metal surfaces. Diagrams equipment and presents industrial applications in finishing processes for magnesium, cadmium, chromium, copper, nickel, and steel in particular.—BTR. 5976

5.5.3, 5.4.5

Rust Protection for Machined and Finished Parts. *Canadian Metals,* **16,** No. 7, 22, 24 (1953) June.

Machined and finished surfaces are particularly prone to corrosive attack during shipping, storage, and stand-by periods. Re-machining is costly and unnecessary if proper precautions are taken. Use of rust preventives such as plastic, oil, thin film, and solvent types is described. Selection of proper type and consistency or viscosity grade represents a compromise between ease of application, the severity of storage conditions, and ease of removal.—INCO. 6280

5.5.3, 6.2.3

Note on the Protection of Mild Steel by Films of Lanolin. E. G. Stroud and J. E. Rhoades-Brown. *J. Applied Chem.,* **3,** No. 6, 287-288 (1953) June.

A solution of lanolin, in white spirit or light mineral oil, can be used for efficient temporary protection if the concentration of lanolin, in either solvent, does not fall below 12.5% by weight, i.e., 0.006 oz. lanolin per sq. ft. (white spirit) and 0.004 oz. per sq. ft. (light mineral oil).—BNF. 6628

5.5.3, 7.1

Navy Studies Anti-Corrosion Gels. J. Carroll. *Aviation Week,* **58,** No. 12, 58 (1953) Mar. 23.

Anti-corrosion compounds for stored aircraft engines are being tested. The new gel is thixotropic, whereby the liquid turning into a hard gel inside the engine breaks down when shaken or stirred so that it reconverts to a liquid on engine operation. Navy tests to determine the capability of the compound to prevent corrosion at high temperatures or under extended storage consisted of applying it at 200° F to 1020 stainless steel panels having a finish similar to an engine cylinder surface. Navy is seeking means of improving the tests in the specification, MIL-C-5545, so that field conditions are more nearly simulated.—INCO. 6358

5.6.3, 5.8.2, 5.4.5

Corrosion Inhibitor. Monsanto Chemicals Ltd. *J. Sci. Instruments,* **30,** No. 2, 62 (1953).

Sodium benzoate has been used successfully in a variety of wrapping and coating materials, the necessary concentration varying up to 5%. The suggestion is made that the inhibitor might be incorporated in protective film forming materials such as latex rubber and paints.—RPI. 6418

5.6 Packaging

5.6.1, 5.4.5, 6.4.4

Storage and Packaging Problems. U. S. Research and Development Board. *Chem. Age* (London), **68,** No. 11768, 817-819 (1953).

A report is given on the present research into storage and packaging problems, the use of strippable vinyl plastic films, control of condensation by storage under reduced pressures, a new protective coating pretreatment for magnesium and vapor-phase inhibitors.—RPI. 6263

5.6.3

Defeating Corrosion. A. R. Black (Shell Oil Co.) and A. Wachter (Shell Dev. Co.) *Ordnance,* **37,** No. 198, 1052-1054 (1953) May-June.

"VPI," a volatile corrosion inhibitor particularly advantageous during storage and shipping of steel products, was pressed into service against industrial and military loss from corrosion. Results of tests, on steel specimens, in humidity cabinets and in outdoor exposure showed that samples protected with VPI-coated paper resisted corrosion. VPI provides protection under arctic, temperate and tropical storage conditions.—INCO. 6221

5.7 Treatment of Medium

5.7.4, 8.1.4

Dehumidified Pipe Galleries. W. W. DeBerard. Chicago Bureau of Eng. *Heating, Piping, Air Cond.,* **25,** No. 2, 73-78 (1953) Feb.

World's largest water filtration plant is also the driest. Dehumidifying equipment eliminated the usual rain-like atmosphere in pump room and filter galleries, checked equipment corrosion, rotting of electrical wire and peeling paint and improved working conditions. Reduced painting requirements alone will amortize the dehumidifying equipment in only 5 years. Illustrations.—INCO. 6650

5.7.4

Prevention of Corrosion by Dehydration of the Atmosphere. H. Netz. *Werkstoffe u. Korrosion,* **4,** No. 1, 2-4 (1953) Jan.

Rusting of machine parts and formation of mildew on walls and ceilings are due to an excess of moisture in the surrounding air. Where large quantities of steam or vapor escape into the air surrounding equipment, the only solution is the use of an air dehydration plant. Enamelling of machinery, ceilings or walls is only a partial solution. Basic theoretical principles of air dehydration are discussed and practical applications given. Introduction of warm air and the extraction of moist air are always necessary. Quantities and temperatures of the incoming air, as well as the amount of heat required are regulated by local conditions. Some numerical problems in the calculation of the individual values are solved by the use of an i-x diagram for moist air.—INCO. 6635

5.7.9, 4.6.2, 7.6.4, 2.2.7

Electrical Treatment of Boiler Feed Waters. T. F. Hurley, H. Ingleson, W. J. Sparkes, and R. Wilkinson. *Corrosion,* **9,** No. 8, 251-258 (1953) Aug.

Two series of tests are reported in which hard makeup water used for small, low pressure steam boilers is examined to determine the effect of electrical treatment of the water on the formation of scale and sludge in the boilers. One test involved boilers specially constructed so they could be taken apart for examination in which two types of electrical treatment devices, one using direct and the other alternating current, were applied to two boilers while two other boilers were fed untreated water as controls. The other test involved boilers in commercial use in which tests with and without electrical treatment devices were made. Examination of the sludge and scale residue as to volume, tenacity, constitution and chemical analysis from both boilers receiving electrically treated and boilers not receiving electrically treated water showed wide differences among the boilers. There was no way, the authors concluded, in which these differences could be associated with electrical treatment of the water.—INCO. 6096

5.8 Inhibitors and Passivators

5.8.1, 4.6.1

Corrosion Inhibitors. Papers before Soc. Chem. Ind., Corrosion Group & Manchester Sect., Symp. on Corrosion Inhibitors, Mar. 27, 1953. *Chemistry & Industry,* No. 22, 537-538; disc. 538-539 **(1953)** May 30.

Papers include: "The Inhibition of Corrosion," U. R. Evans; "Corrosion Inhibitors in Neutral Aqueous Solutions," F. Wormwell; "The Action of Certain Inhibitors in Chloride Polluted Waters," W. S. Patterson and A. W. Jones; "Inhibition by Quinolines and Thioureas of the Acid Dissolution of Mild Steel," T. P. Hoar and R. D. Holliday; "Corrosion Inhibitors for Ethylene Glycol-Water Coolant for Piston Engines," A. T. P. B. Squires; and "Condensed Phosphates in the Treatment of Corrosive Waters," N. D. Parham and C. W. Ted.—INCO. 6289

5.8.2, 3.2.2, 8.4.3

Industry Probes Means of Combating Hydrogen Attack on Steel in Refinery Equipment. W. A. Bonner, H. D. Burnham, J. J. Conradi and T. Skei. Shell Oil Co. *Oil Gas J.,* **1953,** 100, June 8.

Sulfur, added as ammonia polysulfide, was effective in preventing hydrogen attack in refinery equipment. In other

experiments oxygen in place of polysulfide also proved satisfactory. Plant experience with injection of these chemicals and description of permanent plant installation are presented. 6267

5.8.2, 8.4.3, 4.4.6

Kontol 77 Corrosion Inhibitor. *Oil Gas J.*, **52**, No. 1, 152 (1953) May 11.

Kontol 77, a new oil-soluble organic corrosion inhibitor, designed to prevent corrosion and rust formation in pipe lines, tankers, and storage. This inhibitor was developed for protection against acidic components found in crude oils and was demonstrated to be effective against rusting caused by the presence of oxygen in finished petroleum product. Dev. by Tretolite Co.—INCO. 6603

5.8.2, 5.4.5

Effect of (Dicychlohexylamine Nitrite) on Nitrocellulose Lacquers. A. KRAUS. *Fette u. Seifen*, **55**, No. 4, 233-237 (1953).

In an examination of various NC lacquers covering 70 plasticizers and 40 resins, it is shown that the susceptibility of lacquers to attack by dicyclohexylamine nitrite (a vapor-phase corrosion inhibitor) is largely dependent on the plasticizers, resin and pigment. By suitable choice of these, satisfactory properties can be maintained. It is also possible to incorporate the inhibitor in suitable formulations to confer rust-inhibiting properties.—RPI. 6485

5.8.2, 5.8.3, 6.5

Corrosion Inhibitors in Neutral Aqueous Solutions. F. WORMWELL. Paper before Soc. Chem. Ind., Corrosion Group & Manchester Sect., Symp. on Corrosion Inhibitors, Mar. 27, 1953. *Chemistry & Industry*, No. 23, 556-560 (1953) June 6.

Work on corrosion inhibitors at the Chem. Res. Lab. is reviewed. Investigations demonstrated the value of sodium benzoate and sodium salts of other organic acids as corrosion inhibitors for mild steel. By the correct choice of inhibitor, or of a combination of inhibitors, cast iron soldered joints or zinc can be protected. Fundamental investigations are still in progress, employing electrode-potential and radioactive tracer techniques. Results suggest that benzoate is more loosely held on the metal surface than is chromate, explaining the tendency of corrosion to spread out evenly if protection fails in benzoate solutions. Conclusions are drawn regarding the mechanism of corrosion inhibition. Tables and 47 references.—INCO. 6546

5.8.2, 4.6.1, 1.3

Condensed Phosphates in the Treatment of Corrosive Waters. D. N. PARHAM AND C. W. TOD. *Chemistry and Industry*, No. 26, 628-631 (1953) June 27.

These condensed phosphates include Pyro- and metaphosphates with a wide range of glassy materials covered by the term polyphosphates. The glassy phosphates are used for various anti-corrosive purposes including treatment of boiler feed water, prevention of separation of calcium carbonate, prevention of corrosion of galvanized soft-water tanks, etc. This paper is a very useful summary with a bibliography.—BNF. 6448

5.8.3, 2.3.9

The Nature of the Film Formed by Passivation of Iron With Solution of Sodium Phosphate. M. J. PRYOR, M. COHEN, AND F. BROWN. *J. Electrochem. Soc.*, **99**, 542-545 (1952) Dec.; *N. R. C. Res. News*, **5**, No. 3, 4 (1952).

Films formed during passivation of iron in solutions of sodium orthophosphate containing dissolved air have been shown to contain some ferric phosphate in addition to γ—Fe_2O_3. The quantity of phosphate decreases with a rise in pH at constant phosphate content, being about half as great in 0.1 M Na_3PO_4 (pH = 12.2) as in 0.1M $NaHPO_4$ (pH = 9.1). A surface pretreatment involving destruction of the original air formed oxide film by dipping in acid results in high phosphate contents compared with surface treatments involving abrasion at similar pH values. The equilibrium thickness of γ—Fe_2O_3 also formed during passivation is similar to that resulting from exposure of iron to dry air. Weights of ferric phosphate present in films formed by the passivation of iron in 0.1M solutions of disodium and trisodium phosphate were determined using a radioactive tracer, and the thickness of oxide was estimated by an electrochemical method. 5934

5.8.3, 3.8.3, 3.2.3

Metal Surface Phenomena. H. H. UHLIG. Paper before ASM, 33rd Nat. Metal Congr. & Exposition, Detroit, Oct. 13-19, 1951. *Metal Interfaces* (Am. Soc. Metals), 1952, 312-335. *Official Digest Federation Paint & Varnish Production Clubs*, No. 333, 650-670 **(1952).**

Valence forces at the surface of a metal lead to a state of tension of the surface atoms and account for adsorbed films of substances bonded to the metal surface in varying degrees. Adsorbed layers account in major part for friction and lubrication phenomena (rate of wear), catalytic activity, passivity and corrosion resistance, particularly of the transition metals. With especially strong bonding between adsorbate and metal, surface valence forces are satisfied, and the metal surface is relatively inert chemically (becomes passive). The transition metals are active catalytically for many reactions, and are in themselves passive, or constitute the major components of passive alloys like the stainless steels and related corrosion resistant alloys such as the Hastelloys, Stellites, Monels and Inconels. A rapid change in passive properties is expected in solid solution alloys of transition and nontransition metals. Copper-nickel series are a good example. Tables, graphs and 38 references are included.—INCO. 6197

5.9 Surface Treatment

5.9.1

Report on Surface Preparation of Steels for Organic and Other Protective Coatings. TP-6 G—Surface Preparation for Organic Coatings. (Second Interim Report). *Corrosion*, **9**, No. 5, 173-185 (1953) May.

This report describes many mechanical and chemical surface preparation processes, conditions and pretreatments for organic and other coatings that have been used commercially to a greater or lesser extent. Also outlined are good surface preparation practices for galvanized surfaces, maintenance and repair conditioning of surfaces and coatings as well as the assembly of dissimilar metals. 6067

5.9.1, 5.4.5

The Surface Treatment of Ferrous Metals Prior to Painting. H. J. TESTRO. *Sheet Metal Inds.*, **29**, No. 306, 931-940 (1952).

The time lag between metal preparation and painting should be as short as possible. All surface roughening methods which activate the metal surface also tend to accelerate the rate of corrosion and dirt settlement and again necessitte the prompt application of the organic finish. While they may have some detergent action, the use of propripetary processing solutions, including those which convert the metal surface, does not necessarily preclude the prior cleaning of the metal. The complete success of these treatments is often dependent on the observance of the manufacturer's stated recommendations concerning the initial concentration and the maintenance of the solution within certain limits to compensate for drag-out losses, an important consideration on conveyorised flow production lines where this factor may be high. Detergent concentration indicators are marketed for use with alkaline cleaning solutions to ensure correct solution concentration. Other important considerations are the correct bath temperature together with adequate after rinsing and drying to remove all traces of reactive liquids, in which latter connection rinsing tanks may need to be provided with a constant overflow system to avoid contamination and thereby ensure absolute cleanliness. Certain alkaline treatments require an acidulated rinse to ensure neutralization, and vice versa. With some types of pretreatments special attention is also necessary for articles having seams, crevices, or joints, in which the solution may be trapped, and in this connection the particular nature of the work may well dictate the type of pretreatment. Another example of the work dictating the method of pretreatment is provided by articles having protruding threads or machined to close tolerance, which facts may well rule out the use of otherwise suitable pretreatments. The avoidance of undue handling of the cleaned and prepared surface is often overlooked; recommended treatments for the removal of salts deposited from perspiration include the use of alcohol often with the addition of water. Metal pretreatments often produce a somewhat porous surface which, from a painting standpoint, requires necessary building up to achieve a full gloss finish. In general, surface conversion treatments are not removed or impaired when reject painted articles are cleaned off by any non-abrasive methods. The practical value of any of the processing solutions is enhanced by suitable organic finishes, particularly primers possessing inhibition properties and high adhesive value at the metal/paint interface. The newest development incorporating a phosphoric-acid etchant in a specially formulated primer may well be an outstanding contribution towards more efficient metal finishing.—EL. 5868

5.9.1, 5.4.5

Painting Materials and Methods. Parts I and II. J. BROWN. *Pract. Engr.*, **27**; Nos. 677 & 678; 230-232, 266-268 (1953) Mar. 6, Mar. 13.

Part I. The first part of this article deals with methods of cleaning metals in preparation for painting i.e. grit blasting, wire brushing, barrel tumbling, solvent and alkaline degreasing, and pickling. A table lists recommended commercial

alkaline cleaners with notes on their suppliers, uses and operating conditons. Part II. The article continues with advice on the pretreatments to be used before painting aluminum, brass, iron and steel, magnesium, nickel and zinc. Phosphating, chromating or weathering are recommended for zinc surfaces. The installment concludes with a description of the different flinds of paints, lacquers and enamels and of their main uses.—ZDA. 6217

5.9.2, 3.2.2, 3.2.3, 5.8.3

Pickling as a Preparation for Surface Treatment. (In German). R. PETRI. *Metalloberflache*, A, **6**, No. 10, A152-158 (1952).

The author describes experiments to investigate the surface roughening, adsorption of hydrogen, and formation of surface films, which occur during the pickling of metal surfaces. For surface roughness, the Forster-Leitz method of measuring surface micro-irregularities was used, because it gives a 'profile picture' of the surface. 1 mm. thick steel which had been rolled before heat-treatment, was used. A series of pictures is given showing the progressive roughening (etching effect) due to attack by acid in pickling with sulfuric and with hydrochloric acid. The extent of the attack increases with rise in pickling temperature, increase in pickling time, and increase in acid concentration. The effect of inhibiting agents added to the pickling acid was studied. The protective action was marked, but results were not in accordance with Machu's theory that the inhibiting substances were adsorbed on the metal surface. In electrolytic pickling the results can be varied by alternating the current density on the metal surface. Pickling baths used were 10% sulfuric acid, 15% hydrochloric acid and fused sodium nitrite. The rate of attack increased more rapidly with increasing current density when hydrochloric acid was used than with sulfuric acid. Graphs are given showing the amounts of hydrogen liberated during acid pickling at different temperatures and concentrations. The hydrogen which is not liberated is adsorbed and renders the metal brittle. At higher temperatures the proportion of adsorbed to liberated hydrogen increases. The rate of formation of scale deposits on steels of different compositions and the rate of solution of these scales when the steels were used as anodes were also studied. —EL. 5863

5.9.2, 6.2.5, 5.8.2

Contribution to the Study of Pickling the Stainless Steels. G. BATTA, L. SCHEEPERS, L. WINANDY AND G. DALLEMAGNE. *Rev. met.*, **50**, 49-56 (1953) Jan.

Study of composition of oxide films on 18-8. Experiments relate to pickling in hydrofluoric acid/nitric acid/hydrochloric acid; hydrofluoric acid/ferric sulfate; and solutions in which hydrofluoric acid was replaced by less expensive acids (sulfuric acid or hydrochloric acid). Advantages of ferric-sulfate solutions as against hydrofluoric acid/nitric acid/hydrochloric acid and note on effects of various inhibitors of which urea only was efficacious are included. 6225

5.9.3

Remington Rand to Clean Metals by Ultrasonic Method. *Am. Metal Market*, **60**, No. 63, 1, 7 (1953) April 2.

The Detrex Corporation of Detroit, Michigan, U.S.A., has developed a practical method of cleaning by using ultrasonic waves. The "soniclean process" uses a transducer element which is a curved ceramic piece resembling a six-inch long pipe, cut in half along the longitudinal axis. The ceramic pieces, which can be connected in series and arranged as desired, are designed to offer focusing and flexibility properties. In the process, electrical energy is transmitted to the ceramic transducer, converted into sound energy, and projected through a solvent at a frequency of 430,000 cycles per second. The solvent currently being used is trichlorethylene. A potential of only 40 volts is required, thus the ceramic transducers can be safely immersed directly in the solvent. Material to be cleaned is placed in the solvent, directly in the path of the greatest focal intensity of the ultrasonic waves. In this area an extreme turbulence is created, resulting in a deep and penetrating cleaning action that removes almost instantaneously, all dirt, grease, chips and microscopic particles of soil from even the most intricately designed and close-fitting parts. Because of the design of the ceramic transducer, the sound waves converge in a straight line as long as the transducer itself. First commercial equipment using the new process has been purchased by the Electric Shaver division of Remington Rand, Inc., of Bridgeport, Conn. It will permit the precision cleaning of shaver heads at a rate much greater than comparable cleaning methods.—ALL. 6348

5.9.4, 1.6

Phosphating—in Principle and Practice. Book. 1953, 69 pp. Published by Imperial Chemical Industries Ltd., London. *Ind. Finishing*, **5**, No. 56, 468-490 (1953) Feb.

A full report on the conference convened by I.C.I. Ltd., in Birmingham on January 14th, 1953. Two papers were presented: one on plant for phosphating metals, by A. W. Putnam and the other on the performance and control of phosphating processes, by R. J. Brown. Though solutions of various compositions are mentioned, there is no direct reference to specific proprietary brands. The discussions that followed the papers are also reported.—ZDA. 6369

5.9.4

Phosphate Coatings. *Chem. Eng.*, **60**, No. 1, 236 (1953) Jan.

Five new products said to fill every phosphating requirement are Turcoat 3540 for iron, steel or zinc as a bond for paint or metal drawing, Turcoat 3520 for iron or steel as a foundation for oil, paint or other organic finishes, Turcoat 3420 to clean and passivate iron and steel in one operation improving paint adhesion. Turcoat 3557 for phosphate anti-friction coating for iron or steel moving parts, and Turcoat 3560 for chemical coating on terneplate and other difficult-to-coat non-ferrous metals. These are applied by paint or dip and are deposited by Turcoat processes. The coatings are nonconducting and resistant to moisture and chemical changes.—INCO. 6050

5.9.4, 5.4.5

Pretreatment Specifications. Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh 13, Pa. March, 1953, four 8-page pamphlets.

Four pamphlets, each of which recommends an approved treatment for pretreating structural steel surfaces. First specification, Wetting Oil Treatment, defines wetting oils as penetrating oils that oxidize and air-dry to form a solid, water insoluble, protective film. Wetting Oil Treatment is a method of initially saturating the surface layer of rusty and scaled steel with wetting oil that is compatible with the priming paint, thus improving the adhesion and performance of the paint system to be applied. This pretreatment does not, however, take the place of a coat of paint or eliminate the necessity of surface preparation. Pretreatment No. 2, Cold Phosphate Surface Treatment, is a method of converting the surface of steel to insoluble salts of phosphoric acid for the purpose of inhibiting corrosion and improving the adhesion and performance of paints to be applied. No. 3, Basic Zinc Chromate-Vinyl Butyral Washcoat (sometimes referred to as wash primer), is a treatment specified for metals which reacts with the metal and at the same time forms a protective vinyl film containing an inhibitive pigment to help prevent rusting. This washcoat is supplied as two components which are mixed together just prior to use. The base contains an alcohol solution of polyvinyl butyral resin pigmented with basic zinc chromate. The diluent contains an alcohol solution of phosphoric acid which reacts with the vinyl resin, the pigment and the steel. The fourth pretreatment, Hot Phosphate Surface Treatment, covers the procedure required for the hot phosphate surface conversion of structural steel surfaces prior to painting. This gives a high temperature method of converting the surface of steel to a heavy crystalline layer of insoluble salts of phosphoric acid for the purpose of inhibiting corrosion and improving the adhesion and performance to paints to be applied. 6165

5.9.4, 6.2.2

An Electron-Micrograph Study of Oxide Films on Electropolished Surfaces of Iron. E. J. CAULE AND M. COHEN. *Can. J. Chem.*, **31**, No. 3, 237-241 (1953) March.

An electron micrographic study was made of iron surfaces subjected to electropolishing. It was found that although electropolishing produces a relatively smooth surface, the iron is covered with a film. The strengthening of this film by oxidation and its disruption by reduction with hydrogen was followed. The film is assumed to be oxide and its thickness was estimated to be approximately 100 Angstrom units. The effect of reduction of the film on surface area and thus on initial oxidation rates of the reduced specimen was considered. Photographs and references.—INCO. 6276

5.9.4, 6.2.5, 3.4.6, 3.6.6

The Corrosion of Nitrided Stainless Steels in Degassed and Oxygenated Water. H. A. PRAY AND ROBERT S. PEOPLES. Battelle Memorial Inst., Report No. BMI-742, May, 1952. 30 pp.

The corrosion resistance of nitrided 17-4PH and nitrided 322 W stainless steels uncoupled and coupled with various materials, was studied in degassed and oxygenated water at room temperature, 200°F, and 500°F. The coupling materials included Haynes 25, Stellite 3, Stellite 6, Stellite 21, Type 410 stainless, graphite, and Graphitar 14. Chromium-

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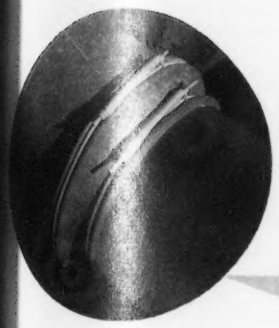

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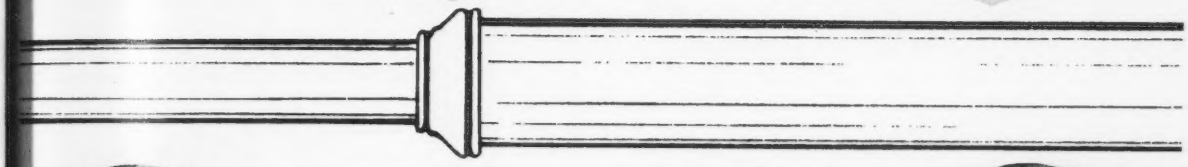

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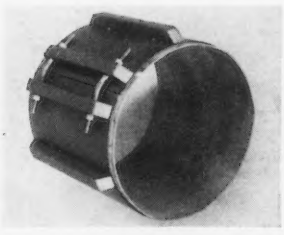

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plated 17-4PH coupled to Haynes 25 was also tested. All uncoupled specimens exhibited satisfactory corrosion resistance to 500° F. water after 1 month's exposure. At room temperature or 200°F., all uncoupled materials, with the exception of the nitrided 17-4PH and 322W alloys, showed satisfactory resistance. These two materials had patches of loose rust, the samples exposed to degassed water appearing less rusted than those exposed to oxygenated water. In the couple tests, the nitrided member of each couple exhigited some rusting after 40 days at room temperature or 28 days at 200°F. Both members of the majority of couples exhibited staining and buildup of rust along the periphery of the contact area. However, the rust buildup appeared to result from the rusting of only the nitrided member. The most severe rusting and buildup occurred at 200°F. in oxygenated water. In general, ground nitrided samples coupled with the various materials exhibited about the same corrosion behavior as did the as-nitrided couples. After two weeks to one month in degassed and oxygenated water at 500°F., none of the materials in the couple test exhibited any red rust. Little or no buildup along the perimeter of the contact area was noted on the Stellite materials coupled with the as-nitrided samples of the 17-4PH and 322W alloys. Pitting was observed on both the degassed and oxygenated water couples. In general, corrosion was less severe at 500°F. than at either room temperature or at 200°F. Of the material combinations tested, only the chromium-plated 17-4PH v. Haynes 25 exhibited what could be construed as satisfactory corrosion properties in oxygenated and degassed water at the three test temperatures.—PDA. 6166

5.11 Design—Influence on Corrosion

5.11, 3.5.8, 4.4.7

Corrosion Factors in Design and Lubrication. F. L. LaQue. Inco. *Product Eng.*, **23,** No. 10, 142-147 (1952) Oct.

Study of the design and lubrication factors contributing to corrosion of metals. Presence of crevices, velocity and turbulence of the corrosive liquid, galvanic couples, active-passive surfaces, fretting corrosion and lubricants are discussed. Table shows the results of fretting corrosion investigation using molybdenum sulfide as an inhibitor. Illustrations.—INCO. 5978

6. MATERIALS OF CONSTRUCTION

6.2 Ferrous Metals and Alloys

6.2.2.

Evolution of Engineering and High-Strength Irons. M. Ballay. *Foundry Trade J.*, **94,** 41-45 (1953) Jan. 8.

Discusses mechanical properties of unalloyed gray irons and alloyed cast irons; methods of heat-treatment; cast irons with spheroidal graphite; corrosion-resisting and special-duty cast iron; and resistance to wear and friction.—BTR. 6224

6.2.2, 6.3.19, 5.8.2, 4.3.2, 6.3.2

Corrosion Inhibition in Acid Solution. Final Report. Cecil V. King and Edward Hillner. New York Univ. June, 1953, 18 pp.

Cylinders of iron, zinc and cadmium were rotated in a highly corrosive solution of acid containing nitrate ion as a depolarizer. Three kinds of inhibitors were added to the solution: dichromate ion plus complexing or chelating agents for metal ions, a wetting or emulsifying agent which is strongly adsorbed and a reagent which forms a very insoluble precipitate with ferrous and ferric ions. Measurements of the effectiveness of these inhibitors are given.—NSA. 6611

6.2.2, 3.2.3, 3.8.4

Study of the Mechanism of the Oxidation of Binary Alloys of Iron-Chromium at Elevated Temperatures. Jean Moreau. *Compt. rend.*, **236,** 85-87 (1953) Jan. 5. (Translated by Mary E. Lee, 3 pp, AEC-TR-2013; CF-53-3-48).

The oxidation in air of iron-chromium alloys containing 2.6, 7.5, 18.0, 23.0 and 30% chromium was studied by subjecting them to 800 and 1250° temperatures and examining the oxides by means of x-ray diffraction and micrography. From these studies a composition diagram has been made and, from previous studies of the solid-state reactions between iron oxides and chromic oxide, the mechanism of the oxidation of the alloys is suggested.—NSA. 6629

6.2.2, 5.8.3, 3.8.3

The Inhibition of the Corrosion of Iron by Some Anodic Inhibitors. M. J. Pryor and M. Cohen. Paper before Electrochemical Soc., Montreal Mtg., Oct. 26-30, 1952. *J. Electrochem. Soc.*, **100,** No. 5, 203-215 (1953) May.

Research to determine whether one mechanism of inhibition could be advanced to explain the passivation of iron by anodic inhibitors. Inhibitors investigated were sodium acetate, benzoate, silicate, carbonate, tungstate and molybdate and sodium chromate, nitrite, hydroxide and phosphate. The iron (0.052% carbon, trace silicon, 0.013% sulfur, 0.028% phosphorus, 0.20% manganese, 0.04% nickel, chromium and copper not determinable) used was in the form of annealed sheet. Solutions of sodium acetate, benzoate, carbonate, hydroxide, orthophosphate and silicate passivate iron only in the presence of dissolved air. If the solutions are deaerated, they attack iron slowly. It is postulated that oxygen dissolved in solution is responsible for passivity by virtue of its heterogeneous reaction with surface iron atoms to form a thin, self-repairing film of γ-Fe_2O_3, 200 Å thick. Oxidizing inhibitors assist in the formation of the passivity films by acting as film repairing agents at discontinuities present during the early stages of film formation. Graphs, tables, 20 references.—INCO. 6523

6.2.3, 3.2.3

The Oxidation of Iron Around 200°C. W. H. J. Vernon, E. A. Calnan, C. J. B. Clews, and T. J. Nurse. *Proc. Roy. Soc.*, Ser. A, **216,** 375-397 (1953) Feb. 10.

Phenomena associated with a critical temperature at about 200° C in oxidation of mild steel sheet in air were investigated by gravimetric, microchemical and electron-diffraction methods. The physical chemistry of the oxide films is discussed in detail. Graphs and tables. 29 references.—BTR. 6618

6.2.2, 3.8.3

Iron Passivation in Nitric Acid. S. Aronow. Harvard Univ. *J. Electrochem. Soc.*, **100,** No. 4, 106C (1953) April.

Experiments to measure the thickness of the layer removed from an iron film in the process of passivation in concentrated nitric acid were carried out. Results corroborate the findings of Gatos and Uhlig. Cold rolled steel and 1 C steel were also used in the investigation. Table.—INCO. 6233

6.2.4, 3.7.2, 6.2.3

Corrosion Resistance of High-Strength Low-Alloy Steels as Influenced by Composition and Environment. C. P. Larrabee. *Corrosion*, **9,** No. 8, 259-271 (1953) Aug.

The corrosion resistances of several high-strength low-alloy steels in various atmospheres, in natural waters and in soil are compared with those of structural copper steel and structural carbon steel in the same environments. The effects of the many variables that influence the corrosion of these steels in the different media are fully discussed. 41 references. 6094

6.2.5, 1.5

Corrosion Forum . . . Stainless Steels. *Chem. Eng.*, **60;** Nos. 4, 5, 6, 7, & 8; 290+, 300+, 302+, 262+, & 260+ (1953) April, May, June, July, & August.

Series on stainless steels with emphasis on those factors which apply to all the common types. Chart data of corrosion resistance for 18-8 grades, the molybdenum-bearing grades, and several straight chromium grades are given. AISI standard and tentative standard types, chemical ranges and limits of stainless and heat-resisting steels are tabulated. Physical and mechanical properties as well as applications of various stainless steels are included. Tables.—INCO. 6243

6.2.5, 3.7.2, 4.3.2, 4.4.2

Studies on the Corrosion Resistant Property of 18-8 Stainless Steel. S. Koshiba, K. Tanaka and A. Inata. *J. Japan Inst. Metals*, **17,** No. 1, 25-27 (1953) Jan.

The authors investigated the corrosion-resistant property of 18-8 stainless steel containing tungsten, molybdenum or copper against hydrochloric acid, sulfuric acid and acetic acid. The results obtained are as follows: The corrosion resistant property against sulfuric acid and hydrochloric acid is improved when tungsten or molybdenum contents are increased; molybdenum is more effective than tungsten. The corrosion resistant property against hydrochloric acid is improved by adding copper, but that against sulfuric acid is decreased. When tungsten, molybdenum or copper is added to the 18-8 stainless steel, the corrosion resistant property against nitric acid and acetic acid is so excellent that the steel is not attacked by those reagents. —JSPS. 6135

6.2.5, 4.3.2, 3.2.2

Some Factors Affecting the Resistance of Austenitic Chromium-Nickel Steels to Attack by Hot Concentrated Nitric Acid. H. T. Shirley and J. E. Truman. *J. Iron Steel Inst.*, **171,** Pt. 4, 354-358 (1952) Aug.

Factors which influence the resistance of normally heat-treated unwelded 18% chromium-13% nickel-1% niobium steel to boiling 70% nitric acid are discussed.

The presence of intercrystalline penetration is characteristic under these conditions, even with steels effectively stabilized against ordinary carbide precipitation effects. Development of a shallow network of intercrystalline penetration contributes to initial increase in rate of attack with time, and large-grained structures make this effect more serious. Purity of acid also influences rate of attack. Small additions of several acid radicals were made, and of these hydrofluoric acid proved most damaging. A greater effect was produced by metallic contamination from dissolved steel, and the main influence is due to the chromium content of the solution. This effect of metallic contamination falls off rapidly with reduction in acid strength, and in practice is probably not serious below 60% nitric acid. Tables, graphs and photomicrographs.—INCO. 5914

6.2.5, 3.2.3, 2.3.7

An Investigation of Intergranular Oxidation in Stainless Steel; Quarterly Progress Report. C. A. SIEBERT, M. J. SINNOTT, AND R. E. KEITH. Engineering Research Inst., Univ. of Mich. 1953, June. 9 pp.

Oxidation tests of 100 hours duration on stainless steel have been carried out at temperatures of 1600, 1700, 1800 and 1900° F at an air flow of 20 fpm and penetration measurements were made on these specimens. Intergranular penetration varied in depth from 0.0003-in. at 1600° F to 0.003-in. at 1900° F. In general, depth penetration and its standard deviation increase with increasing oxidation temperature. A discussion of metallographic appearances of the penetrating material at different temperatures, particularly at 1800° F is given. Equipment and procedures used in the investigation are described.—NSA. 6493

6.2.5, 3.2.3, 3.8.3

Amount of Oxygen on the Surface of Passive Stainless Steel. H. H. UHLIG AND S. L. LORD, JR. Paper before Electrochemical Soc., Montreal Mtg., Oct. 26-30, 1952. *J. Electrochem. Soc.*, **100**, No. 5, 216-221 (1953) May.

The amount of oxygen on the surface of 18-8 (0.045% carbon, 18.50% chromium, 9.43% nickel) was obtained by pickling the alloy with hydrochloric acid-sulfuric acid, washing with nitrogen-saturated water, then exposing the metal to water of known dissolved oxygen content. The decrease in dissolved oxygen for a definite period of exposure was a measure of the oxygen taken up by the 18-8 surface. Take-up of oxygen was rapid the first few minutes, then proceeded slowly, reaching maximum, after 6 hr., of 1.1 microgram/apparent cm^2 of metal surface. The alloy attained maximum passivity after about 3 hr. in aerated water. The maximum amount of oxygen on passive 18-8 based on so-called true surface area is 0.27 $\mu g/cm^2$. It is proposed that oxide films previously isolated from stainless steels by several investigators were produced by reaction of the adsorbed film with the metal, the reaction being induced by polishing and abrading, presence of halogen ions and water in the stripping solution, or by high temperatures. Such oxide films are considered to be of secondary importance in accounting for passivity as measured by corrosion resistance and by a noble potential. Tables, graphs, 21 references.—INCO. 6525

6.2.5, 6.2.4

Developments in Alloy Steels; A Review of Recent Progress. C. SYKES. *Metallurgia*, **47**, 3-8 (1953) Jan.

Places main emphasis on field of corrosion and heat resisting steels. Reference is made to high-speed and boron steels and use of rare earths as alloying elements. Also includes niobium steels, corrosion resistance and intergranular corrosion of stainless steels. Tables, diagrams, photographs. 30 references.—BTR. 6562

6.2.5

17% Chromium Stainless Steel. *Machine Design*, 25, 118-122 (1953) June.

Shows that the above is an effective replacement for nickel-bearing stainless steel. Corrosion resistance, mechanical properties, performance at low and high temperatures, magnetic properties, weldability, weld design, brazing, soldering, stamping, drawing, forming, spinning, machining and surface finish. Photographs, tables.—MR. 6375

6.2.5, 3.2.2

Corrosion Cracking of Martensitic Stainless Steel. A. E. DURKIN. General Electric Co. *Metal Progress*, **64**, No. 1, 72-75 (1953) July.

Cracking of 12% chromium stainless steel is apparently the result of hydrogen embrittlement and not of stress-corrosion as such. Embrittlement results from surface corrosion that releases hydrogen which then diffuses into deformed metal structures. If these cracking failures were the result of stress, ductility could not be recovered by the mild and simple treatment of immersion in hot water. Embrittled steel can be relieved by heating in water or by heating at temperatures up to 500° F. This will prevent cracking, but does not eliminate susceptibility to future embrittlement. Results of stress tests on Type 410 in caustic soda, cold and boiling concentrated hydrochloric acid and in a solution of hydrochloric acid and selenium dioxide are illustrated and discussed. Illustrations, 2 references.—INCO. 6394

6.2.5

Corrosion M. G. FONTANA. *Ind. and Eng. Chem.*, **45**, No. 7, 91A-92A, 94A (1953) July.

Corrosion of Durimet 20 and Carpenter 20 by nitric acid as a function of temperature is summarized in chart form, and compared with 18-8S. These materials exhibit excellent corrosion resistance up to about 100° F and also to boiling acids up to about 50% strength. Composition, including nickel content and mechanical properties, which are essentially the same as the austenitic stainless steels such as 18-8S are tabulated.—INCO. 6398

6.2.5, 5.8.2, 5.8.3, 4.3.2

The Influence of Potassium Dichromate on Stainless Steel in Deaerated Sulphuric Acid. I. D. G. BERWICK. *Chemistry and Industry*, No. 17, 408-409 (1953) April 25.

Present studies established that potassium dichromate passivates austenitic 18/8 chromium-nickel stainless steel in sulfuric acid in the complete absence of oxygen, provided the dichromate exceeds a certain concentration. It is suggested that the mechanism of dichromate inhibition involves a direct oxidation of the surface of the stainless steel. 5 references.—INCO. 6415

6.3 Non-ferrous Metals and Alloys—Heavy

6.3.6

New Alloy. *Battelle Tech. Rev.*, **2**, No. 4, 44 (1953) April; *Chem. Eng. News*, **31**, No. 14, 1416 (1953) April 6.

New copper-base alloy, Alloy A 114, predicted by H. J. Jackson, D. B. Roach and R. B. Fisher, Battelle, to replace the scarce and expensive beryllium-copper alloys for some uses contains 10% nickel, 1.5% silicon, and 4% aluminum. It has good electrical conductivity, high corrosion resistance and good springiness. Cost of the new alloy is expected to be less than that of the copper-beryllium alloys when manufacture is on a mass-production basis. A pound of beryllium metal is currently priced at $71.50 as compared to prices below $1.00 for the substitute alloy materials, nickel, silicon, and aluminum.—INCO. 6252

6.3.6, 3.2.3, 3.7.2

On the Improvement of Imitation Gold. On the Tarnish-Resistant Properties of Copper Alloys. T. OKAMURA AND T. KIMURA. *J. Japan Inst. Metals*, **17**, No. 3, 153-156 (1953) Mar.

The imitation gold, which has been investigated by the authors, has the defect of tarnishing by perspiration in practical use. The present investigation has been carried out on tarnish-resistant properties of copper alloys by measurement of the tarnishing rate and by observation of the colors produced by tarnishing, using salt, lactic acid, urea and sodium sulfide as experimental reagents. In binary copper alloys, the tarnish-resistnace to salt is improved by adding zinc; against lactic acid nickel and silver are effective, and $\alpha + \beta$ phase alloy of the copper-zinc system is also good. No remarkable effects are obtained particularly in the case of sodium sulfide, nevertheless it is of interest that the tarnish-resistant property is improved by nickel, in spite of its weakness against sulfide. The tarnishing by urea is negligible. Oxide films, produced by selective oxidation of aluminum-copper alloys, are highly protective against tarnishing.—JSPS. 6149

6.3.6, 3.5.9

Picturesque "Whisker" Growth on Copper. R. J. WAKELIN. *Bull. Inst. Metals*, **1**, No. 20, 186-187 (1953).

A letter. Whisker growth has been observed on copper maintained at 200 V above earth and slowly heated to 850°C, held for 24 hours and slowly cooled in an atmosphere changing from air to a mixture of nitrogen, carbon monoxide, carbon dioxide, methane and hydrogen. The whiskers vary in diameter from 0.01 to 0.001 cm, are polycrystalline, have the same lattice spacing as the block and have parallel grooves running along their length, reminiscent of extrusions. It is tentatively suggested that they may be forced out by the pressure of steam generated within the lump. However, the association with a potential above earth and their occurrence largely at the corners of lumps, suggest a connection with electrical discharges.—MA. 6638

6.3.6, 2.2.2, 2.2.7, 4.2.5, 4.6.11

The Corrosion of Beryllium Copper Strip in Sea Water and Marine Atmospheres. J. J. RICHARDS. Am. Soc. Testing Materials, Preprint No. 71, 1953, 18 pp.

Copper-1.9% beryllium-0.25% cobalt

and copper-2.7% cobalt-0.5% beryllium alloys were exposed to a marine atmosphere (80 ft. and 800 ft. from the sea) and were immersed in the sea in quiet conditions and in water flowing at 3 ft./sec. for periods up to two years. Rotating disc and jet impingement tests were carried out and electrode potentials and polarization curves measured. Copper-beryllium was somewhat more resistant in the atmosphere than P.D.O. copper or phosphor bronze. In immersed conditions it was in general equal to, or slightly better than, copper or Admiralty brass and inferior to phosphor bronze or 70/30 (0.4% iron) copper-nickel.—BNF. 6641

6.3.6, 1.3

Copper and Copper Alloys: A Survey of Technical Progress During 1952. E. Voce. *Metallurgia,* **47,** 9-17 (1953) Jan.

Covers production, foundry practice fabrication, finishing and plating, properties and applications, corrosion and protection, joining, physical metallurgy, powder metallurgy, analysis and testing. 205 references.—BTR. 6646

6.3.6

Corrosion Resistance of Beryllium Copper. John T. Richards. *Corrosion,* **9,** No. 10, 359-371 (1953) Oct.

Available data are presented on the resistance offered by beryllium copper to corrosion by various media including fresh and salt water, acids, alkalies and liquid metals. Attack by various atmospheres is considered and the resulting corrosion products are described. The possible role of internal oxidation or sub-scale formation is also discussed. Other forms covered include galvanic corrosion, cavitation erosion, stress-corrosion and corrosion fatigue. The effect of corrosion on the processing of beryllium copper products is noted, while typical applications where corrosion may present a problem are briefly reviewed. 6621

6.3.6, 2.3.7, 3.5.8, 3.4.8

Stress-Corrosion in Special Copper Alloys. O. Lissner. *Sheet Metal Inds.,* **30,** No. 1, 45-55 (1953) Jan.

Electrolytic copper and thirteen copper alloys, including a 14.7% zinc alloy, a silicon brass, a tin brass, six aluminum-manganese brasses, two aluminum bronzes, a tin bronze, and a beryllium bronze were tested for stress-corrosion susceptibility by soaking the test pieces in ammonia water above room temperature. The highest degree of attack was obtained by dissolving copper in the ammonia solution prior to testing to obtain a high concentration of cupritetramine ions. Although these conditions never occur in practice this test has the advantage that the conditions governing corrosion can be accurately determined and at the same time are independent of the dimensions of the test piece and the quantity of liquid employed. The ratio between the life of a specimen exposed to ammonia solutions with and without copper additions ranges from 1:8 to 1:10. If smaller quantities of liquid and bigger specimens are used, this ratio should be lower. Samples in the form of tensile test pieces meet the requirements of well-defined tensile stresses and of large evenly exposed surfaces necessary for comparable stress-corrosion testing.

Only one of the thirteen alloys, 7% tin-bronze, was invulnerable, even at high stresses. The aluminum bronzes were slightly vulnerable. Alloys exhibiting a partial α-structure, but devoid of arsenic, should be used with certain reservations. Aluminum brasses containing arsenic are highly vulnerable.

Because all test alloys were cold-worked to some extent, the results obtained apply only to this condition and would probably be different for annealed alloys. With the exception of the aged beryllium bronze, all alloys examined were homogeneous solid solutions. The occurrence of both transcrystalline and intercrystalline cracks is explained as follows: Localized attack starts at lattice dislocations surrounded by a stress field in which the solubility of the atoms is increased. Where the crystals have suffered no deformation, the dislocations are confined to the grain boundaries so that intercrystalline cracking occurs. Cold-work displaces the dislocations, and they become blocked by the mosaic pattern or traverse the crystals and thus give rise to transcrystalline cracks (β-brass). These dislocations are assumed not only to increase local stresses but also to change the concentration of alloying elements, which ultimately determine the path of the crack. Such changes are absent in pure copper and consequently no stress corrosion occurs. —PDA. 6435

6.3.6, 3.7.2, 3.5.9

High-Temperature Oxidation Characteristics of a Group of Oxidation-Resistant Copper-Base Alloys. J. P. Dennison and A. Preece. *J. Inst. Metals,* **81,** Pt. 5, 229-234 (1953) Jan.

Influence of separate additions of aluminum, beryllium, chromium, magnesium and silicon on high-temperature oxidation of copper was determined by correlating rates of oxidation with composition and microstructure of the oxides formed. Effectiveness in conferring oxidation resistance was in the decreasing order of beryllium, aluminum, magnesium, silicon and chromium.—INCO. 6393

6.3.6, 3.7.3, 3.2.2

Hydrogen Blisters in Brass Sheet. R. Eborall and A. J. Swain. *J. Inst. Metals,* **81,** Pt. I, 497-500 (1953) July.

Blisters appearing near the center plane of brass sheet were attributed to hydrogen collecting and persisting in central voids of the cast slab, so that these voids did not weld up during rolling; expansion of the compressed hydrogen on annealing the brass after it had been reduced to thin sheet and so was unable to withstand the stresses produced, caused the appearance of blisters. It was found that hydrogen was lost during annealing and an effective remedy was developed based on this observation and on a proposed mechanism of blistering. Approximate measurements of the solubility of hydrogen in solid 2:1 brass gave values lower than the published values for copper. Tables, graphs and 4 references.—INCO. 6550

6.3.6, 3.2.3, 3.4.6

The Oxidation of Copper in the Temperature Range 200°-800°C. R. F. Tylecote. *J. Inst. Metals,* **81,** No. 12, 681-700 (1953) Aug.

Measurement of weight changes (using a continuously recording balance) in oxidation of high-purity copper up to 100 hr. Effect of different atmospheres (air, oxygen, "oxygen free" nitrogen and air containing water vapor), specimen shape and other factors.—BNF. 6497

6.3.8, 5.3.2, 8.8.1

Lead and Lead Alloys. Kempton H. Roll. Lead Industries Association, New York. *Chem. Eng.,* **60,** No. 2, 264+ (1953) February.

Chemical lead, acid lead, or copper lead are generally specified for chemical construction. They contain small percentages of silver and copper that improve the resistance of lead to creep, fatigue and corrosion. Corrosion-resistant alloys include antimonial or hard lead usually containing about 6-8% antimony and tellurium lead containing about 0.04% tellurium. Lead-base alloys for special exposure conditions include tellurium antimonial lead, 7% tin lead, calcium lead and other alloys containing silver or other elements in fractional perenctages. Lead and most of its alloys can be rolled, extruded, or cast. Lead-clad steel or copper combines the corrosion resistance of lead with the strength of steel or the high heat transfer of copper. Lead joints used for corrosion-resistant equipment are made by fusion welding. This process insures that no metal less resistant than lead will be exposed to corrosive attack.

Lead relies on a thin protective coating for its high corrosion resistance. If the coating is a highly insoluble lead salt such as the sulfate, carbonate, or phosphate, resistance to corrosion is high and the environment generally promotes selfhealing on mechanical injury. If a soluble film forms such as the nitrate, acetate, or chloride, little protection is afforded and the lead may corrode further. Where corrosives do not readily form a protective film and will not dissolve lead sulfate, a lead lining can often be made corrosion-proof by swabbing or filling the vessel with dilute sulfuric acid. Lead generally has good resistance to neutral solutions where lead carbonate and possibly oxide are corrosion products. It has fair resistance to alkaline solutions in which these salts are soluble. It is commercially resistant to chromic, sulfuric, sulfurous and phosphoric acids but subject to corrosion at higher rates by hydrochloric and hydrofluoric acids. It is susceptible to acetic, formic and nitric acids.

Because operating conditions vary widely, it is usually wise to make actual exposure tests under operating conditions to forecast performance in a specific application. Corrosion rates based on actual plant tests conducted under operating conditions do not, however, necessarily represent the highest concentrations or temperatures under which lead would serve satisfactorily. The corrosion rate may be expected to decrease at lower temperatures and, in most cases, lower concentrations.

Corrosion resistance of lead and lead alloys to a number of corrosives, such as acids, alkalies and salts both organic and inorganic, is given in chart form. The forms available, fabrication and applications in the chemical processing industries are summarized. 6579

6.3.9, 6.3.10, 4.3.2, 3.6.5, 3.6.8

On the Behavior of Molybdenum and Nickel and Some Molybdenum-Nickel Alloys in Acid Electrolytes. (In German). G. Masing and G. Roth. *Werkstoffe u. Korrosion,* **3,** No. 5/6, 176-186 (1952) May-June.

The steady potential of the molybde-

num electrode depends on the pH. This dependence is explained by analogy to antimony. The normal potential of the $Mo/MoO_4^{=}$ —ions is calculated $E_o^{II} = -0.20$ volts. In the anodic dissolution, if the current density is not too small, the molybdenum follows the relation of Tafel. Divergences are explained as overlaid cathodic reactions and the steady potential as strongly polarized. Dependance on pH of the rising of Tafel's straight line is described. A method for indirect measurement of oxygen-depolarization on different metals is described. Absolute determination of the oxygen molecularly dissolved in the electrolyte by electrochemical means can be made. In accordance with the results of polarization trials, the internal current on molybdenum is 10^{-6} A/cm². Comparison with the steel shows for the internal current density approx. $i_{Fe} = 100\ i_{Mo}$, while the relation $i_{Fe} = 2i_{Al}$ nearly corresponds with the values stated in literature. This outcome supports the supposition of a very vast surface-covering of the molybdenum electrode. From the results, the acid resistance of molybdenum and its alloys can be comprehended theoretically. 48 references.—INCO.
6543

6.3.9, 3.5.9, 5.3.4

Introductory Plating Studies on Protecting Molybdenum from High-Temperature Oxidation. L. E. Vaaler, C. A. Snavely, and C. L. Faust. Battelle Memorial Inst. April 1, 1953, 20 pp.

Electrodeposited nickel protected molybdenum from air oxidation for 100 hr. at 1800°F. The best samples lost only 0.1 to 0.2% of the original sample weight (about 3 g). Nickel was deposited on molybdenum after various pretreatments: 1) a-c electrolysis in hydrofluoric acid; 2) a dip in alkaline ferricyanide solutions; or 3) a combination of anodic cleaning in alkali, a dip in nitric acid and a dip in alkaline ferricyanide. In most cases, a thin layer of chromium or iron was deposited prior to nickel deposition. All deposits blistered when heated to 800°F in a vacuum (100μ) except when iron was deposited prior to the nickel. Nickel, one mil thick, deposited directly on molybdenum or over a chromium plate, protected molybdenum for 100 hr. at 1800°F, but nickel over iron on molybdenum was not so effective. Attempts were unsuccessful to deposit copper which would not blister on molybdenum when heated. —NSA.
6526

6.3.10

A New Corrosion Resistant Alloy (Hastelloy F): Its Properties and Possible Uses. Haynes Stellite Co. *Materials & Methods*, 37, No. 5, 92-93 (1953) May.

Hastelloy F is a new nickel-chromium-molybdenum-iron alloy claimed to resist attack by oxidizing and reducing acids, alkaline solutions, pitting and stress corrosion cracking in chlorine solutions. Nominal composition 45.5% nickel, 22% chromium, 6.5% molybdenum, 2% niobium + tantalum (tantalum 0.5% min.), 0.8% max. C, 1.5% manganese, 1% max. tungsten, 2.5% max. cobalt, balance iron. The alloy has not yet been fully tested. —BNF.
6390

6.3.10, 3.2.3, 3.7.3, 3.7.2

Electron-Diffraction Study of Nickel Surfaces Tarnished in the Course of Heat-Treatment in Hydrogen. (In Eng-

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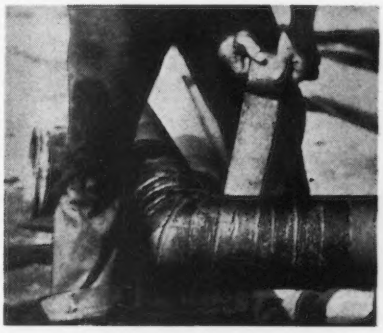

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lish). SHIRO OGAWA AND DENJIRO WATANABE. Science Repts. Research Insts. Tohoku Univ., A, **4**, No. 1, 41-47 (1952).

Nickel plates for use in vacuum tubes, annealed in hydrogen at approximately 900°-1000°C. often tarnish and acquire a milk-white appearance, which considerably reduces their commercial value. This tarnishing and the milk-white appearance have been shown by electron-diffraction studies to be due to the presence of silicates of light metals. Silicates, e.g. (Mg, Ca) SiO_3 and Mg_2SiO_4, must be removed during melting, as if even a small amount remains dispersed throughout the material, it may gradually collect in the grain boundaries during heat-treatment of the nickel and cause tarnishing of the surface.—MA. 6093

6.3.10, 4.3.6

The Action of Metallic Nickel on Bismuth Trichloride. E. H. CORNISH. *J. Applied Chem.*, **3**, Pt. 3, 106-109 (1953) March.

Nickel reacts with dilute aqueous solutions of bismuth trichloride with deposition of elementary bismuth. There is, however, a range of concentration of the salt within which nickel has no action at 25°. At higher temperatures other factors intervene and smooth reaction occurs. The rate of reaction is increased by moderate stirring but decreases with increasing acid concentration. Tables and references.—INCO. 6286

6.3.10, 7.6.6, 4.3.2, 4.6.11, 3.5.8

Alloy F Is Corrosion-Resistant, Stronger Than Austenitic Steels. *Chem. Eng. News*, **31**, No. 12, 1232 (1953) March 23.

Hastelloy Alloy F, developed by Haynes Stellite Co., is composed of nickel, molybdenum, chromium and iron and contains small quantities of niobium, tantalum and manganese with traces of other elements. It is designed to be intermediate in price, workability and corrosion resistance between the austenitic stainless steels and the nickel-molybdenum alloys. It is said to be resistant to boiling sulfuric acid in concentrations under 20% and to air-free sulfuric in concentrations up to 30% and temperatures up to 176°F. It resists pitting by sea water and stress corrosion. Electrical resistance and thermal conductivity approximate those of 18-8. It can be welded by metallic arc, inert gas shielded arc and by resistance welding methods. Only industrial use was for lining a sulfite pulp digester constructed for A. O. Smith Co. Illustrations.—INCO. 6260

6.3.13

The Kinetics of Formation and Structure of Anodic Oxide Films on Tantalum. (In English). D. A. VERMILYEA. *Acta Metallurgica*, **1**, No. 3, 282-294 (1953) May.

Rate of formation was studied using aqueous electrolytes. Thicknesses of films were measured by comparing the interference colors with a calibrated step gage. Graphs, tables, micrographs.—BTR. 6479

6.3.15, 6.3.18, 6.3.20, 4.7

Behaviour of Titanium, Vanadium, and Zirconium Towards Fusion Reagents. R. S. YOUNG AND K. G. A. STRACHAN. *Chemistry and Industry*, No. 7, 154-155 (1953).

A note. Reactions of 1-2 g specimens of titanium, vanadium and zirconium sheet in contact with laboratory reagents are noted. With sodium sulfate (50 parts to 1 of metal) in a Pyrex "copper" flask, vanadium and zirconium were completely dissolved in 45 minutes and titanium in 1½ hours. On fusion with liquid sodium hydroxide (30 g to 1 g of metal) for 2 hours, vanadium completely dissolved and titanium was slightly more resistant, whereas zirconium was covered with a hard thin black scale, under which virtually all the metal remained intact. With sodium carbonate after 2 hours most of the vanadium had dissolved and the remainder was very brittle, while black films were formed on titanium and zirconium and loss in weight (16% and 5%, respectively) occurred. With sodium peroxide (30 parts to 1 of metal) in an iron crucible, titanium and vanadium reacted vigorously and dissolved in 10 minutes and 2 hours, respectively, while zirconium developed a hard grey film and underwent a loss of only 4 wt.—%. In view of its resistance to attack by molten alkalies, it is suggested that zirconium could be used as a crucible material for sodium hydroxide fusions.—MA. 6627

6.3.15, 3.5.8, 5.8.2

Stress-Corrosion Cracking of Commercially Pure Titanium. G. C. KIEFER AND W. W. HARPLE. Allegheny Ludlum Steel Corp. *Metal Progress*, **63**, No. 2, 74-76 (1953) Feb.

Search for a corroding medium for stress-cracking titanium in a short time using commercially pure titanium (Titanium Metal Corp. Alloy 75A) with 0.01-0.04% carbon, 0.04-0.05% silicon, 0.02-0.04% nitrogen, 0.01-0.04% tungsten, approx. 0.10% iron. Its general corrosion resistance in chloride solutions was excellent. Red fuming nitric acid at room temperature produced cracks in stressed samples in time varying from 3-16 hrs. Samples exposed in the vapors alone cracked after several weeks' exposure. Microscopic examination showed the cracking to be intergranular. Addition of 1% by weight sodium bromide prevented cracking even after several weeks' exposure. Illustrations.—INCO. 6612

6.3.15, 8.9.1

Titanium—Today and Tomorrow. I. Today. II. Tomorrow. *SAE J.*, **61**, 20-24; 56-65 (1953) May, June.

Presents information taken from The Bases for Tonnage Titanium Production, C. I. Bradford; Titanium Alloys for Aircraft Engine Forgings, L. R. Frazier; Titanium Alloy Development, M. Hansen and H. D. Kessler; Titanium in Airframes, F. R. Kostock and Utilization of Titanium and Other Alloys in Corrosive Environments, W. L. Williams. Photographs, diagrams.—BTR. 6632

6.3.15, 6.3.9, 6.3.20, 6.3.21

Titanium, Molybdenum, Zirconium and Hafnium. *Materials & Methods*, **37**, 125 (1953) June.

Data sheet gives physical, mechanical and fabricating properties; thermal treatment, corrosion resistance, available forms and uses. Table.—MR. 6408

6.3.15, 3.6.6, 3.4.8

Certain Aspects of the Galvanic Corrosion Behavior of Titanium. D. SCHLAIN. U. S. Dept. Interior Bureau of Mines, Report of Investigations No. 4965, April, 1953, 22 pp.

Experimental study of some factors important in the galvanic corrosion of titanium. Electrode potentials of titanium immersed in solutions of sodium chloride, hydrochloric acid, sulfuric acid or sulfurous acid changed with time and approached steady rates. Titanium is passive in hydrochloric acid in the presence of air and cupric ion, but loses its passivity, after a time, when in contact with small volumes of stagnant 10N hydrochloric acid containing cupric ion. There was no chemical or galvanic corrosion of titanium in 3% sodium chloride solution, but magnesium, zinc, aluminum, iron and copper corroded as a result of being coupled with titanium. Stainless steel did not corrode by galvanic action. Titanium generally corrodes by galvanic action with a flow of helium and copper becomes the corroding medium in air. Dissolved copper in these solutions appeared to affect the corrosion of titanium-copper couples and the chemical corrosion of titanium. Illustrations, 18 references.—INCO. 6565

6.3.16, 6.3.13, 6.3.5, 6.3.18

Tungsten, Tantalum, Columbium and Vanadium. *Materials & Methods*, **37**, 127 (1953) June.

Data sheet gives physical, mechanical and fabricating properties; thermal treatment, corrosion resistance, available forms and uses. Table.—MR. 6381

6.3.19, 3.7.2, 5.3.2, 2.2.2

The Effect of Impurities in the Metal on the Rate of Corrosion of Zinc and Galvanized Coatings in the Atmosphere. P. T. GILBERT. *J. Applied Chem.* (London), **3**, No. 4, 174-181 (1953).

Results of exposure tests carried out by the British Non-Ferrous Metals Research Association on zinc and zinc-coated steel specimens over a number of years are summarized with reference to 1) the corrosion behavior of rolled zinc sheets of differing purity in various atmospheres, and 2) the effects of additions to the galvanizing bath on the corrosion-resistance of hot-dipped coatings exposed to the atmosphere in the Euston district of London. In general, the rate of attack on solid zinc over a 3-year period was not greatly affected by the presence of $\leqslant 1\%$ lead and smaller amounts of cadmium, iron and copper, but the corrosion rate of zinc-copper alloys (2% copper) in industrial atmospheres was approximately 20% lower than that of zinc under similar conditions; in marine environments, the zinc-copper alloys, though initially slightly superior, were not significantly more resistant than zinc after three years. The rate of attack on zinc sheet in industrial atmospheres increased with time and it is considered that the climatic conditions during the first few days' exposure may affect the behavior of the zinc during the first few years. The life of the galvanized coatings was proportional to the coating thickness and was apparently unaffected by the presence of $\leqslant 3\%$ aluminum or tin, 1% antimony or 10% cadmium in the bath.—MA. 6345

6.3.19, 3.7.2, 3.2.2

Intercrystalline Corrosion in Cast Zinc-Aluminum Alloys. C. W. ROBERTS. *J. Inst. Metals*, **81**, No. 6, 301-309 (1953) Feb.

An account of research undertaken to determine the susceptibility of zinc-aluminum to intercrystalline corrosion in an atmosphere of air and water-vapor at 95°C. Compositions within the range

aluminum 0-22%, copper 0-1.5%, magnesium 0-0.09%, lead, tin and cadmium 0-0.030%, bismuth 0-0.016% and manganese 0-0.050% were tested in the as-cast condition. It was found that intercrystalline corrosion was confined to the α (zinc-rich) phase, though it was more severe when the β —phase was also present. Small amounts of lead, tin, cadmium and bismuth greatly increased the severity of attack, but small magnesium additions reduced it, whether impurities were present or not, provided the magnesium did not form intermetallic compounds with the impurities. Copper increased the resistance of two-phase alloys to intercrystalline attack. The results are compared with those of other workers and theories are proposed to explain some aspects of the phenomena.—ZDA. 6503

6.3.20, 5.9.4, 3.2.3, 3.5.9

The Inhibition of Gas Phase Reactions of Zirconium by Anodic Oxide Films. Part 2. J. J. Polling and A. Charlesby. Atomic Energy Research Establishment, Harwell, Berks (England). May 27, 1953, 14 pp.

Experiments have been conducted to determine the effect of electrolytically formed oxide films on the subsequent gas uptake by zirconium at high temperatures. At 435°C there is an appreciable decrease in the rate at which gases enter the system when an electrolytic oxide is present on the surface. If allowance is made for the presence of the initial oxide layer on the anodized specimens, the weight increase-time curve is similar for all specimens. The anodized specimens gain weight at the same rate as non-anodized specimens after these have been heated in air for a time sufficient to produce the same oxide thickness as was obtained electrolytically. It is concluded that there is no difference between oxide layers obtained thermally or electrolytically; moreover, the weight increase on heating in air up to 600°C appears to be due to surface oxidation alone and not to dissolution of atmospheric gases in the metal, at least for films up to 10^4 Å in thickness.—NSA. 6554

6.3.20, 8.4.5, 3.4.6

Latest Developments in Zirconium—A Report on the Symposium at the Western Metal Congress. Papers before Western Metal Congress, Los Angeles, Mar. 23-27, 1953. *Materials & Methods*, **37**, No. 5, 174+(1953) May.

Papers Include: Zirconium in Nuclear Reactors, E. C. Miller; Manufacture of Hafnium-Free Zirconium Sponge, S. M. Shelton; The Newest Consumable Electrode Arc Melting Techniques, H. L. Gilbert; Fabrication of Zirconium, R. F. Gordon; Benefits of an Oxide Film for Drawing of Zirconium, H. L. Gilbert and R. M. Treco; Methods Used to Make Zirconium Powder and the Uses of Such Powders, H. S. Kalish; Corrosion Resistance of Zirconium, L. B. Golden; Physical Metallurgy of Zirconium, W. L. Mudge, Jr.; Oxygen Pick-Up and the Effects of Oxygen, R. M. Treco.

Papers are briefly discussed. Several zirconium phase diagrams which were studied, including zirconium-silicon, zirconium-tin, zirconium-nickel and zirconium-manganese, were presented at the Congress.—INCO. 6420

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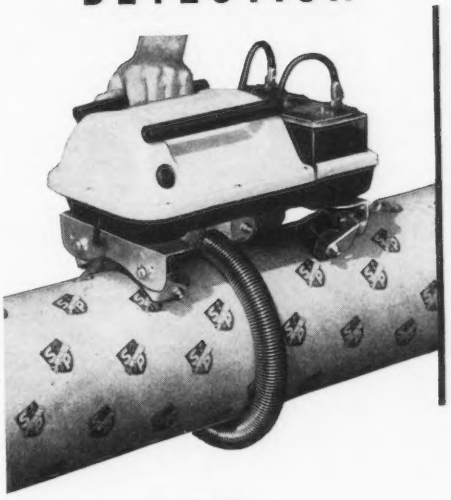

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6.4 Non-ferrous Metals and Alloys—Light

6.4.1, 5.5.3

Preservation of Light Metal. G. DALLMEYER. *Aluminum*, **29**, No. 5, 189-194 (1953) May.

The use of "preservatives" is customary to protect semi-finished and finished light metal products from corrosion which might occur during unfavorable storage and service conditions. Tests using a new self-emulsifying corrosion inhibiting oil, (Shell-Korrosionsschutzöl A—Shell Protective Oil A) which has given excellent results under most severe test conditions. As compared with oils previously used, the new oil has the advantage that its effectiveness is not impaired by methods of application nor the film thickness by heat and solvents. The ready emulsifiability of the new oil will make its application possible in most fields of the aluminum industry, e.g. for cooling and lubricating during rolling, drawing, machining. Tests are also described using vaseline type preservatives (Shell-Korrosions-schutzfett). These tests confirmed the favorable behavior of the preservative reported earlier when used for overhead aluminum cables and installations in the open air, as well as to prevent corrosion on welded and riveted joints.—ALL. 6403

6.4.1, 5.4.5, 2.2.2

Priming Paints for Light Alloys. J. G. RIGG AND E. W. SKERREY. *J. Inst. Metals*, **81**, Pt. 10, 481-489 (1953) June.

Results obtained from the exposure of light alloy specimens for 3½ years in rural, industrial and marine atmospheres, with various primers under aluminum top coats. Zinc chromate and zinc tetroxychromate primers were superior in protective value to iron oxide primer, although the latter provided satisfactory protection, especially to aluminum in the less severe environments. Red lead primer was definitely harmful on light alloys, and especially on magnesium in corrosive environments. In these tests both types of chromate primer were found to be slightly preferable to red lead on mild steel. Zinc chromate and zinc tetroxychromate pigments are preferred for primers for composite structures of steel and light alloys in severe exposure conditions, while iron oxide is adequate for milder conditions.—INCO. 6642

6.4.1, 5.9.4, 5.9.1

Surface Treatment and Finishing of Light Metals: Part 8. S. WERNICK AND R. PINNER. *Sheet Metals Ind.*, **30**, No. 315, 571-583 (1953) July.

The series is continued with a discussion of electrolytic chemical polishing processes. While mechanical polishing produces a flowed amorphous surface under the influence of pressure and high local temperatures, chemical and electropolishing are selective dissolution processes, by which the asperities of the rough surface are dissolved faster than depressions. The potential advantages of these methods are obvious, a) being similar in operation to anodizing and electroplating processes, they can be employed together in a single production line, with considerable reduction in plant and simplified control, while mechanical polishing can be replaced entirely; b) they are suitable for bulk treatment and labor costs are much lower, particularly on components not suited to automatic polishing machines; c) the surface is clean and gives better deposit adhesion, as well as high corrosion resistance; d) the reflectivity and the color are often superior and there is no tendency to "bloom." There are two types of industrial and chemical polishing for aluminum. The first is designed to replace mechanical polishing. It provides a smooth and bright, though not a mirror, finish and is characterized by high dissolution rates (above 0.0001 in./mm) and may be used in commercial grades of aluminum and most wrought alloys. The second type is used as a finishing treatment after mechanical polishing. In this case there is a slow rate of attack and it is used on aluminum reflectors, as well as anodized applications (natural self-color or dyed) which require a higher specular reflectivity than is obtained by mechanical methods alone. The following industrial electropolishing processes are described, the Brytal Process, the Alzac Process, Phosphoric Acid Processes, the modern Battelle Electropolishing Process and other phosphoric acid processes. Chemical polishing is discussed from the point of view of theory and from industrial processes which are based on phosphoric acid to which nitric acid, sulfuric acid and acetic acid as well as other compounds may be added. 50 references are cited.—ALL. 6589

6.4.2, 2.2.2, 4.2.1

Resistance of Aluminum Alloys to Weathering. C. J. WALTON, D. O. SPROWLS AND J. A. NOCK JR. *Corrosion*, **9**, No. 10, 345-358 (1953) Oct.

Extensive data selected from tests of many thousands of specimens of aluminum alloys, exposed in various natural atmospheres for periods as long as 20 years, are presented graphically. These data provide comprehensive coverage of the resistance to weathering of outstanding types of wrought and cast aluminum alloys, with particular emphasis on alloys used in architectural and structural applications. Effects of weathering were evaluated by measurement of change in strength and depth of attack of specimens exposed for periods up to 20 years in natural atmospheres and for as long as 52 years in actual service.

Aluminum alloys have been evaluated in a sufficient number of different types of atmospheres at widely separated geographic locations to predict with reasonable assurance the performance expected under most conditions normally encountered. The corrosion of aluminum alloys, both wrought and cast, exhibit a "self stopping" characteristic; that is, the rate of attack after an initial exposure period of about one to two years decreases to a very low value, generally to less than 0.2 mil per year. The aluminum alloys displayed high resistance to corrosion and although some differences were noted, these differences often were subordinate to other characteristics of interest, such as strength, formability, appearance and cost. 6583

6.4.2, 8.1.2, 4.2.4

Corrosion Resistance of Aluminum to Coal Gas. *Engineer*, **195**, No. 5067, 365 (1953) Mar. 6.

To ascertain the suitability of aluminum alloys as a structural material in a gasworks, an aluminum roof was installed over the dry purification plant at the Sevenoaks, Kent, Gasworks. It was built in February 1948 by the Aluminium Construction Company Limited using material supplied by the Northern Aluminium Company, Ltd. No paint or other form of protection was applied to the structure. Alloy sections used were to British Standard Specification H. E. 10 and corrugated sheet to Specification N. S. 3. Although the original brightness has disappeared, the condition of the roof, after nearly five years, shows very little evidence of deterioration, only slight surface roughening and pitting being revealed by a superficial examination. In January 1952, Aluminum Laboratories Limited examined a structural member and a roofing sheet and found evidence of only very slight corrosion. A metallurgical examination of the sectional material indicated that the mean depth of pitting corrosion was 0.0173-inch. Since the thickness of the flanges and web of the member was ¼-inch and 3/16-inch respectively, the amount of peneration showed that the tensile properties were still in excess of the minimum specified for H. E. 10 material. The maximum depth of the pitting on the inner surface of the sheet specimen, which as 0.028-inch thick, was 0.0047-inch while only superficial corrosion was found on the outer surface. Again, tensile tests revealed that the pitting had not caused the properties of the sheet to fall below the minimum for N. S. 3 material. Based on these results aluminum alloy roofs have been used in Wandsworth and Guildford.—ALL. 6592

6.4.2, 4.2.5, 2.2.2, 2.2.7

Corrosion Resistance. *Iron Age*, **172**, No. 8, 145-146 (1953) August 20.

After a recent study, the National Bureau of Standards indicated that corrosion resistance of both clad and unclad 24S-T3 aluminum alloy stapled together with galvanized steel wire may be "satisfactory" for some types of installations. Stapled specimen sheets of this alloy, were exposed in a marine atmosphere and in the tidewater. Results for exposure periods up to 37 months are discussed in this article, and indicate that both types of sheet joined in this fashion have satisfactory corrosion resistance for service in marine atmospheres.—ALL. 6595

6.4.2, 4.3.2

The Behaviour of Aluminium Towards Hydrofluoric Acid, Phosphoric Acid, Chromic Acid and Their Mixtures. (In German). W. WIEDERHOLT. *Metall*, **7**, No. 9/10, 343-347 (1953) May.

Hydrofluoric acid, phosphoric acid each attack aluminum and aluminum alloys without the formation of protective coatings. An addition of phosphoric acid to dilute hydrofluoric acid does not decrease but rather increases the attack. It was established however, that the weight loss was considerably smaller when phosphoric acid was added to chromic acid. An addition of chromic acid to hydrofluoric acid delays attack only when the chromic acid additions are small. Nevertheless, protective coating formation is possible with mixtures of hydrofluoric acid, phosphoric acid and chromic acid, if the hydrofluoric acid concentration is comparatively small and if the additions of chromic acid are kept within a certain limit. —ALL. 6614

6.4.2

Industrial Painting of Aluminum Products. H. J. TESTRO. *Paint Manuf.*, **23**, 86-89, 93 (1953).

Aluminum exposure to highly humid, salt-laden, acid or alkali atmospheres results in the formation of a white corro-

sion product. Alloying aluminum with other metals for the improvement of its mechanical properties may result in greater susceptibility to corrosion and atmospheric tarnishing. Methods of surface preparation for aluminum and aluminum alloys are reviewed as well as cleaning methods and other treatments. Suitable paint finishes and notes on methods of stripping paint films from these surfaces are considered.—ALL. 6631

6.4.2, 3.7.2, 2.3.5

On the Age-Hardenable and Corrosion-Resistant Aluminum-Magnesium-Silicon Ternary Alloys. M. KATO, Y. SASAKI and K. TAKETANI. *Light Metals* (Japan), No. 6, 56-62 (1953) Feb.

The solvus surface at aluminum corner in aluminum-magnesium-silicon ternary diagram was determined by means of electrical resistivity measurement. As the result, it was decided that the most favorable alloys as high-tensile and corrosion-resistant alloy were A(1.1% magnesium, 0.65% silicon, balance aluminum) and B (0.75% magnesium, 1.3% silicon, balance aluminum) alloy. The former corresponds to the principal composition of Alcoa 53S and the latter the one of Alcoa A' 51S and B.S. AW10. In the next place, a study on the influences of copper and iron on the tensile properties and corrosion resistances of A and B alloy were carried out. Copper increases the tensile strength, while it decreases markedly the corrosion resistance. Iron decreases the age-hardenability and corrosion resistance. So in case of services under the severe environments, for example marine use, the content of copper and iron should be as low as possible.—JSPS. 6162

8. INDUSTRIES

8.4 Group 4

8.4.3, 5.8.2

Deep Well Acidizing. F. E. RUGG. Dowell Inc. *Petroleum Eng.*, **25,** No. 7, B-68-B-69, B-72 (1953) July.

Discussion on the requirements of deep well acidizing from the standpoint of equipment, typical case histories and specialized acid solutions and chemical additives including a solvent known as mud acid which reacts with silicates and bentonitic materials, surface tension lowering and emulsion prevention agents, plugging materials, silicate-control agents and a high-temperature inhibitor which does not break down at temperatures as high as 400° F and which protects well equipment from acid corrosion at all normal deep well temperatures. Basic chemical used in acidizing is an aqueous hydrochloric acid solution (usually 15% concentration) containing an inhibitor which protects the metals in well equipment from corrosive attack by the acid, without interfering with the reaction between the acid and the formation. Illustrations.—INCO. 6605

8.4.3, 3.5.8

What to Do About Amine Stress Corrosion. G. L. GARWOOD. Phillips Petroleum Co. Paper before NGAA, Houston, 1953. *Oil Gas J.*, 52, No. 12, 334-335, 337-340 (1953) July 27.

Stress corrosion cracking found in water-amine gas treaters used for the removal of hydrogen sulfide and carbon dioxide from natural gas is described. Most effective method found by Phillips Petroleum Co. to prevent this stress corrosion cracking is to stress relieve new equipment and to employ stress-relieving after welding has been done on old equipment. Process modifications have been reasonably successful. 3 references.—INCO. 6460

8.4.3, 7.2, 1.2.2, 3.4.6

Casing Corrosion in West Texas-New Mexico. R. L. ELKINS. *Corrosion,* **9,** No. 9, 321-324 (1953) Sept.

Internal casing corrosion in the upper gas-filled portion of the tubing-casing annulus is a costly and widespread problem in the West Texas-New Mexico area. Severity of the problem is illustrated by experiences in the Wasson Field where an estimated $1,400,000 was spent in casing repairs during the first fifteen years after development of the field and other large losses occurred which could not be estimated. This problem also has been detected in at least six other large fields in the area.

It is believed that corrosion results from the condensation of moisture on the casing interior and subsequent absorption of acid gases. All findings to date substantiate this theory.

Corrosion of this type is being controlled by packing off and filling the tubing-casing annulus with a noncorrosive fluid, thereby excluding the corrosive gases and protecting the casing from future failures. Application of this protective measure costs about $1200 per well as compared to the $3000 to $40,000 expenditure for repair operations in the event of a casing failure.

Other promising protective measures, which would be more easily applied and less costly if effective, are currently being tested. 6463

8.4.3

Corrosion Control in Oil Refineries. Means of Protection in Process Plant. *Petroleum Times,* **57** (1953) Jan. 23.

Covers corrosion occurring in refinery vessels as a result of refining process. Control of corrosion in steam-raising equipment and in cooling water circuits, and hydrogen sulfide and hydrogen chloride as most serious sources of chemical attack are described. Other causes of corrosion are reviewed. Linings as protection ("guniting," plastics, etc.) and desalting, demulsifying and electrostatic processes are included. When distillation stage is reached, control is by chemical treatment and through use of special materials. Monel or 12% chromium steel is used as lining for flash section in atmospheric towers. Top tray is of high-alloy steel (12% chromium upward) or of Monel. Steel is often used against hydrogen sulfide and Monel against hydrogen chloride. Conditions in which attack is most likely to occur are given. Corrosion and erosion in catalytic crackers are discussed. Materials of construction include a steel with 25% chromium, 12% nickel for pumps. 18/8 is used because of high creep strength and good corrosion-resistance. Most severe application is for cast tube supports in heaters (35/15 chromium-nickel type). Warning regarding correct use of fuels containing vanadium and sulfur and short reference to low-temperature operations and to use of austenitic steels and pure metals, i.e., nickel, copper, lead are included.—INCO. 6151

8.4.3

Don't Let Corrosion Eat Up Your Profits. D. H. CARPENTER. Sohio Petroleum Co. *World Oil,* **136,** No. 2, 172-174 (1953) Feb. 1.

Corrosion profitably controlled in practically all producing oil and gas wells. Rate of corrosion is measured by analysis of the produced brine to determine dissolved iron content, by exposing a pre-weighed coupon and measuring the inches of penetration per year, and by the caliper survey. Corrosion control measures include use of inhibitors, use of corrosion resistant materials and the use of neutralizers. Effectiveness of these measures is given in table form.—INCO. 6278

8.4.3, 1.7.1, 3.2.2

Studies on Water-Dependent Corrosion in Sweet Oil Wells. H. E. GREENWELL. *Corrosion,* **9,** No. 9, 307-312 (1953) Sept.

It has been known for a number of years that corrosion problems occur in the operation of sweet oil wells. General recognition of this fact has been brought about recently as a result of concerted efforts of the NACE TP-1 Committee. It is the purpose of this paper to summarize the present understanding of sweet oil well corrosion problems and to discuss means of detection and control. The greater part of the data which support the views given in the paper have been collected by the TP-1C Subcommittee on sweet oil well corrosion and by various individuals associated with the TP-1 Committee work.

It has been established that two distinct types of corrosion occur in sweet oil wells. One type, which has been known as "high pressure corrosion," occurs in wells producing as little as 0.1% water. The other type usually occurs in lower pressure wells and is related to a critical percentage of water production. This paper considers both types of sweet oil well corrosion with regard to the causative agents, controlling physical factors, statistics of occurrence and severity and control measures. Emphasis is placed on the most recent developments in the studies of "low pressure" or water dependent type of sweet oil well corrosion. 6129

8.4.3, 5.4.5, 5.2.1, 8.9.5

Corrosion. Some Problems in the Petroleum Industry. *Petroleum Times,* **57,** 63-71, 73-78 (1953) Jan. 23.

Comprised of "The Use of Paints as Protectives in the Fight Against Corrosion: A Survey of Their Effectiveness," A. D. C. Hamilton; "Cathodic Protection Against Corrosion," G. G. Portch; "Corrosion Problems in Oil Tankers"; and "Corrosion Control" in Oil Refineries."—MR. 6155

8.4.3, 7.3

How to Select a Subsurface Pump Plunger to Fit the Job. K. N. MILLS. *World Oil,* **136,** No. 6, 224+ (1953) May.

Oil well lifting costs can be kept at a minimum by selecting the type of subsurface pump plunger to fit the job, since the design and construction of the plunger influence the initial cost of the pump and its service life. Effects of corrosion on pump efficiency depend on the degree of activity of the corrosive agent. Under conditions of mild corrosion, it can be responsible for limited wear which is the combined result of mechanical and chemical action. When the fluid is highly corrosive, plunger and barrel materials with good corrosion resistance should be chosen. Fluid slippage, various types of plungers and increasing

service life are discussed. Illustrations.—INCO. 6465

8.4.3, 7.2, 2.2.1, 2.2.3

Gas-Condensate Operations at Reddell. D. E. Gregg. *Oil Gas J.*, **52,** No. 7, 190+ (1953) June 22.

Corrosion at Reddell was detected by several different methods, including iron analysis of produced waters, surface and subsurface exposure of weighed steel coupons and tubing-caliper surveys. Two methods of protecting the tubing included the pumping of liquid chemicals into the tubing-casing annulus and the use of corrosion-inhibitor sticks.—INCO. 6427

8.4.3, 7.4.2, 7.6.4, 7.6.8

How Corrosion of Gas-Treating Plants Is Being Studied. G. W. Cronenberg. *Oil Gas J.*, **51,** No. 51, 267-268 (1953) April 27.

Studies of corrosion reduction in El Paso Natural Gas Co.'s gas treating equipment are described. These include: removal of every third vertical row of tube bundles in the reboilers to reduce tube cuttings, use of chromium-molybdenum alloy in the reboilers, removal of hydrocarbon gases and hydrogen sulfide from the solution stream to reduce heat exchanger tube cutting. Inlet gases of low carbon dioxide to hydrogen sulfide ratios corroded mainly carbon steel while high carbon dioxide to hydrogen sulfide gas attacked mainly cast-iron parts of the treating plant stills. Corrosion in the stills was smallest in the regions having a thick iron sulfide deposit. Removal of half of the bubble cap teeth has lengthened the life of contactors used in solution reclaiming. Inhibited admiralty is much more corrosion-resistant in solution cooler tubes than is carbon steel. 6423

8.4.3, 7.3, 7.4.2, 4.6.4, 4.6.11

Some Corrosion Problems Encountered in Mina-Al-Ah-Madi Refinery. V. J. Chir, F. H. Colenutt, and K. Turner. Paper before Persian Gulf Branch of Inst. of Petroleum, May, 1952. *Inst. Petroleum Rev.*, **7,** 159-164 (1953) May.

Deals with problems in the Kuwait Refinery pertaining to actual processing of crude and to use of seawater as cooling medium. Short description is given of distillation unit. In soda system, caustic embrittlement in pumps, body impellers, covers and wearing parts, which were of Type 347 stainless steel, led to replacement by Meehanite (Moly C.1) for body end covers and impellers, Monel for wearing rings and spacer sleeves and Stellited 11/13 nickel-chromium steel for shaft sleeves Full account of performance of admiralty brass condenser tubes in seawater cooling system is given. Corrosion was encountered and means for control are described. As a long-term policy, 70/30 cupro-nickel tubes were ordered, although less costly aluminum brass tubes would probably have served as well in existence of low water velocities. It is hoped that the known higher corrosion-resistance of cupro-nickel tubes will facilitate trouble-free operation for an economical period under the conditions obtaining.—INCO. 6416

8.4.3, 5.8.2

Oil Field Scale and Corrosion. E. N. Frisius. Magna Prods., Inc. *World Oil*, **136.** No. 7, 191-192, 194 (1953) June.

By using adequate corrosion mitigation, the amount of tubing footage and sucker rods to be replaced is reduced. Use of the scale and corrosion inhibitors is discussed. Comparative records before and during treatment with inhibitors are tabulated.—INCO. 6402

8.4.3, 5.8.3, 5.8.2

How Inhibitors Prevent Corrosion in Oil Wells. Pts. 1, 2, 3, & 4. T. N. Newell. Cardinal Chem. Inc. *Oil Gas J.*, **51,** Nos. 40, 41, 42, & 43; 145, 175, 207, & 103 (1953) Feb. 9, Feb. 16, Feb. 23, & Mar. 2.

The mechanism by which the best oil-well inhibitors function is to impart to oil the ability to wet steel and to form an impenetrable tenacious film of polar molecules on the steel surface which prevents corrosive brine from contacting the steel surface. The basic building blocks for the polar compound are long straight-chain hydrocarbons. Physical adsorption and chemisorption which are 2 mechanisms by which materials adsorb on surfaces, polarity and wetting ability are discussed. Experimental results indicate that oil-soluble and oil-soluble water dispersible inhibitors are more efficient than water soluble inhibitors. 18-8 which was used in a lube-oil solvent-extraction unit where corrosion was occurring is giving good service with no appreciable corrosion loss. Illustrations.—INCO. 6371

8.4.3, 7.2, 5.8.2, 2.2.1

South Louisiana Operators Wage Fight on Four Types of Corrosion. J. T. Martin. *Oil Gas J.*, **52,** No. 7, 308-314+ (1953) June 22.

Four types of corrosion, including water independent, water dependent, hydrogen sulfide and galvanic are discussed covering oil and gas wells. Water analysis, metal coupons and tubing-caliper surveys are used in detecting corrosion. The corrosion resistance of 9% nickel steel used in flush-joint tubing is felt to be higher than J-55 or N-80 steel tubing, but it does not appear to be free from corrosion attack. Chemical inhibitors, in liquid or stick form, are introduced into the casing annulus of corrosive pumping wells. Tables.—INCO. 6538

8.4.5, 6.4.2

Aluminum Comes of Age in a Nuclear World. N. F. Ritchey. Reynolds Metals Co. *Iron Age*, **172,** No. 5, 94-97 (1953) July 30.

Light weight, good corrosion resistance, low-neutron absorption rate, efficient heat transfer and ability to bond well with uranium make aluminum a highly acceptable material for nuclear reactors. Because of its low-neutron absorption rate and rapid rate of radioactive decay, work can be done on a reactor after only several hours wait. Because it is nonmagnetic and a good electrical conductor, it is an essential part of the electrostatic generator of Argonne National Lab. Canning uranium, storing heavy water and making reactor cores are a few of its uses. In North Carolina State College's homogeneous reactor, an aluminum envelope surrounds the active stainless steel core containing the uranyl sulfate. Illustrations.—INCO. 6626

8.4.5, 6.3.20

Engineering and Technical Problems of Atomic Power. W. H. Zinn. Argonne Nat. Lab. Paper before Am. Power Conf., Chicago, Mar. 25, 1953. *Combustion*, **24,** No. 12, 49-52 (1953) June.

With high heat fluxes, cooling surfaces must not foul. Also, corrosion products in the circulating fluid become radioactive and add to the maintenance and shielding difficulty. Zirconium is quite resistant to attack under conditions of high-temperature and high-pressure. Compatibility, corrosion-wise, of the uranium fuel with its coolant has a great deal to do with the extent to which the protecting sheath must be made perfect. This aspect of corrosion is in addition to the usual one of interference by the corrosion products with the heat transfer properties of surfaces. It makes corrosion research basic to the development of nuclear reactors.—INCO. 6557

8.4.5, 7.4.4, 4.7

Nuclear Power Plants—Design and Performance of Liquid-Metal Heat Exchangers and Steam Generators. R. D. Brooks and A. L. Rosenblatt. Knolls Atomic Power Lab. Paper before Am. Soc. Mech. Engrs., Heat Trans. Div., Ann. Mtg., N. Y., Nov. 30-Dec. 5, 1952. *Mech. Eng.*, **75,** No. 5, 363-368 (1953) May.

Design consideration indicated liquid-metal coolants to be promising for use with the nuclear-energy sources to produce power. At the time of design, the only weldable materials suitable for use with Na and NaK were L-nickel and Type 347 stainless steel. The high thermal conductivity made nickel desirable for tube material. For this unit it was decided to use nickel for the entire heat exchanger. This made the joining of the tubes to the tube sheet a simple rolling and seal welding operation. Graphs and 9 references.—INCO. 6364

8.5 Group 5

8.5.3

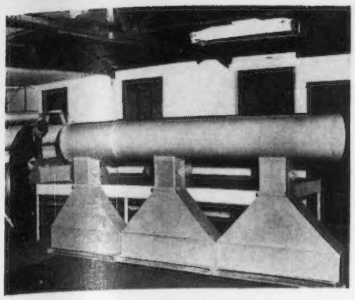
A Review of the Operation of the Tomlinson Secondary Recovery System. J. Allan. Canada Paper Co. Paper before Can. Pulp & Paper Assoc., Tech. Section, Ann. Mtg., Montreal, Jan. 28-30, 1953. *Pulp & Paper Mag. Can.*, Conv. Issue, **54,** No. 3, 202-204 (1953).

The Tomlinson secondary recovery system was installed at the Canada Paper Co., to recover the chemical and heat from the effluent gases from a new 175 ton B & W Tomlinson furnace. Approximately 100 lb. of sodium salts are recovered for each air-dry ton of pulp produced and in addition, a heat recovery of 4 x 10^6 BTU per a.d. ton is obtained. ½ of the nozzles were Spraycо 250F flat spray nozzles; remainder were 7L solid cone, cast iron nozzles. Header was fabricated from lengths of extra heavy steel pipe with welded joints. Diagram of the system is given.—INCO. 6368

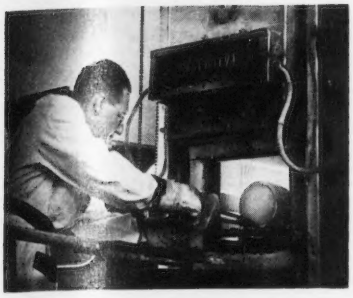
8.5.3, 7.6.6, 7.3

Nekoosa Kraft Pulp Mill Modernizes and Expands. R. A. Nugent. *Paper Trade J.*, **136,** No. 4, 24, 26 (1953) Jan. 23.

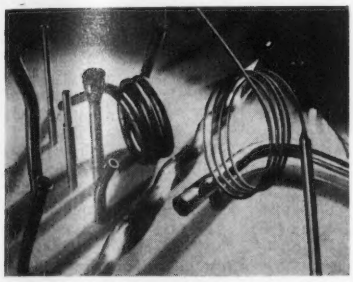
Discussion of the modernization and expansion program. Wood room, vacuum evaporator, alkali, wet room and bleach plant are considered. New digesters are made of Grade C fire box quality steel and are equipped with stainless steel strainers. Circulating pumps, also stainless steel, are 2400 GPM capacity and are spring mounted. The two-pass heaters are of stainless steel, Type 304. Photographs.—INCO. 6379



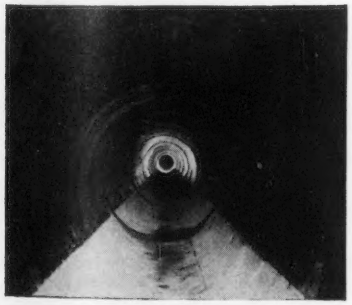
Polyester laminate fabrications



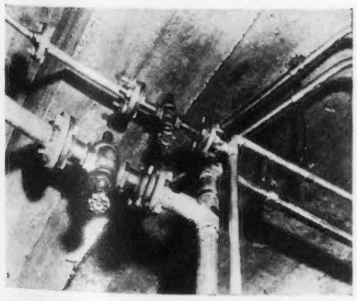
High temperature ceramics



Small gauge alloy tubing



Linings and coatings for pipe



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8.5.3

Recovery Operation Corrosion Problems. H. O. TEEPLE. Inco. Paper before Technical Assn. Pulp & Paper Ind., 6th Alkaline Pulping Conf., Mobile, Nov. 12-14, 1952. *TAPPI*, **36**, No. 7, 127A-128A (1953) July.

Discussion of recovery operation corrosion problems in the furnace, boiler and auxiliaries largely based on carbon steel as the material of construction. Materials recommended are stainless steel wear plates in the salt cake dissolving tank where abrasion occurs, stainless or Ni-Resist pumps for transferring black liquor with dissolved cake to the recovery furnace, stainless steel [18-8, 25-12 (Type 309) or 25-20 (Type 310)] smelter spouts, and Type 316 for the flue gas duct. In general, corrosion of carbon steel components of a precipitator can be minimized if attention is paid to the maintenance of adequate temperatures in the precipitators. Reference is made to chromium-iron stainless steels, copper-base and aluminum alloys and Type 304 stainless steel. Venturi scrubbers and oxidation of black liquor are briefly discussed. 7 references.—INCO. 6606

8.5.3

The Oxidation of Sulphate Black Liquor. T. T. COLLINS, JR. *Paper Trade J.*, **136**; Nos. 12 & 13; 37-40, 19-22 (1953) Mar. 20, Mar. 27.

Review of literature on the oxidation of sulfate black liquor. Stabilization of some of the sulfur compounds in sulfate black liquor appears to be one of the most interesting of recent chemical developments for the kraft process. 67 references.—INCO. 6285

8.8 Group 8

8.8.1

Preserving What You Have from the Corrosion Engineer's Viewpoint. E. A. TICE. Inco. *Chem. Eng. Progress*, **48**, No. 7, 329-332 (1952) July.

Effect of operating factors such as aeration, or the presence of oxidizing agents, velocity or media flow, or agitation, and temperature on the corrosion resistance of metals and alloys is discussed. These factors are illustrated by the performnace of Monel in sulfuric acid. Graphs and illustrations.—INCO. 5971

8.8.1

Our Experience with Corrosion. R. C. THIEDE. General Aniline. *Chem. Eng.*, **60**, No. 3, 344, 346-348 (1953) Mar.

Discusses problems and some solutions of maintaining equipment handling mineral acids, organic chemicals, brines and cooling waters. Pipelines and valves of steel were replaced with stainless steel. Lead equipment was replaced with with tellurium-lead coils. The use of paints and the attention that should be given to keeping the equipment clean are discussed.—INCO. 6492

8.8.1, 4.3.2, 6.2.5

Nitric Acid in Great Britain. G. C. INSKEEP AND T. H. HENRY. *Ind. & Eng. Chem.*, **45**, No. 7, 1386-1395 (1953) July.

Billingham plant of Imperial Chemical Industries, Ltd., which produces nitric acid by the ammonia oxidation process incorporated the first all-stainless steel absorption unit in Great Britain. Most vessels and pipelines in the nitric acid plant are of 18% chromium, 8% nickel, 1% titanium stainless steel because this alloy is completely immune from weld decay or any crystalline disintegration which was encountered with a straight 18-8 alloy. Its corrosion resistance is excellent in hot nitrous gases. Platinum-rhodium alloy gauze supported on a chromium-nickel mesh resting on bars of the same material is the catalyst used. The alkaline absorption tower is of mild steel and the pumps are of cast iron or mild steel. Sodium-nitrate process, ammonium oxidation process and the process of thermal fixation of nitrogen are discussed. A list of the nitric acid plants in U. S. as of June 1, 1953, is tabulated. Illustrations, flow sheet, tables, 22 references.—INCO. 6544

8.8.1, 4.3.6

Ammonium Nitrate. W. H. SHEARON, JR. AND W. B. DUNWOODY. Miss Chemical Corp. *Ind. & Eng. Chem.*, **45**, No. 3, 496-504 (1953) March.

In the Miss. Chem. Corp. which produces ammonium nitrate, all tanks, including the neutralizer, are of Type 347 stainless steel. The pipe-lines are mostly Type 347 with some Type 304 and the evaporators and bagging equipment are of stainless steel. Impurities such as copper, zinc and certain other materials and the formation of aqua regia (highly corrosive to stainless steel) in the acid tower should be guarded against. When dry ammonium nitrate picks up moisture and/or goes into solution, it causes corrosion problems. There were no failures in the carbon steel drying and cooling drums which were stress-relieved after fabrication and the stainless steel vessels. Concrete foundations for equipment which deteriorated as ammonium nitrate solution was spilled on them or as dust went into solution were replaced with carbon steel I-beams coated with asphalt-based paint. Illustrations, flow sheet, 26 references.—INCO. 6561

8.8.1, 4.3.6, 7.6.5

Modern Plant for Salt Production. A. W. BAMFORTH. *Times Rev. Ind.*, **7**, 28-29 (1953) May.

Description of Krystal process and of various units designed by A/S Krystal and by Power-Gas Corporation. Special reference is made to design and fabrication of triple-effect Krystal evaporator installation designed to produce 300 tons per day of 99.9% sodium chloride from raw brine. First evaporator fabricated was entirely in solid nickel and is among largest solid nickel vessels ever constructed in Great Britain; second and third effect evaporators are composite constructions of high-grade cast iron and nickel. Design of nickel shells follows general requirements laid down in B.S. 1500. Account of steps taken to preclude contamination by sulfur during fabrication is included. Calandrias consist of one nickel tube/mild steel unit for first effect and two pairs of nickel tube/cast iron units arranged in series for second and third effects. Liquor-circulating lines are of nickel, pumps being of Ni-resist.—INCO. 6353

8.8.1, 6.2.5

Corrosion of Stainless Reduced by Materials and Process Controls. D. R. KECK. *Can. Chem. Processing*, **37**, No. 1, 40, 42 (1953) Jan.

Steps taken by Canadian Chemical Co. to prevent corrosion failures in stainless steel equipment at their Edmonton plant are outlined. Causes of corrosion, types of corrosion including crevice, joint, and concentration cell and methods of combating them are noted.—INCO. 6404

8.8.1, 2.3.8

Production of Acetic Anhydride from Acetone. W. G. DAROUX. Paper before Soc. of Chem. Ind., Jt. Mtg., Chem Eng. Group & Inst. Chem. Engrs., Mar. 31, 1953. *J. Applied Chem.* (London), **3**, Pt. 6, 241-252 (1953) June.

Pilot-plant process evaluation and full-scale design for the production of acetic anhydride from acetone are described. Preheat and cracking tubes, furnace coils, condensing and absorption equipment, stills and pumps are of 25/20 chromium-nickel stainless steel. Illustrations and 10 references.—INCO. 6475

8.8.1, 6.2.5

The Dependence of the Canadian Chemical Company on Mining and Metallurgy. D. R. KECK. Paper before Ann. Western Mtg., Winnipeg, Oct. 1952. *Can. Mining Met. Bull.*, **46**, No. 489, 28-31 (1953) Jan.

At the Bishop plant, in Texas, of the Celanese Corp. of America, stainless steel equipment failure due to the presence of acids was a serious problem. Because 316 stainless steel produced during WW II was of general low molybdenum content which resulted in high corrosion rates, use of a modified 316 stainless steel (0.07% carbon, 2.25% molybdenum, 17% chromium, 11-14% nickel) was permitted. Solutions to corrosion problems, such as intergranular corrosion, corrosion from chemical attack, stress cracking of stainless tubes, crevice corrosion, pitting of gasketed joints in stainless piping, concentration-cell type of corrosion in underground water pipe and fretting corrosion, at Bishop which were similar to those at the Edmonton plant of the Canadian Chemical Co., Ltd., are discussed. Illustrations.—INCO. 6466

8.8.1, 3.1

Practical and Theoretical Aspects of Corrosion in a Chemical Plant. (In German). MAX WERNER. *Z. Metallkunde*, **44**, 37-43 (1953) February.

Experience with metals in the chemical industry shows that electro-chemical laws are of little help in the field of industrial corrosion. What determines the resistance of metals is primarily the durability of the protective films formed in the given surroundings. A good protective film must be dense, resistant to erosion and must adhere firmly to the substrate.

In 80% of all corrosion cases, the cause can be traced to some form of destruction of the protective film by mechanical factors, thermal shock or chemical attack. The other 20% involve special forms of corrosion which either are unrelated to or overshadow the destruction of the surface film. Intercrystalline and transcrystalline stress corrosion can occur simultaneously with the destruction of the protective film. Other types of corrosion are grain disintegration, as in austenitic steels, oxygen corrosion characterized by pitting, local galvanic cell formation, dezincification of brasses, blister formation in lead platings, "comet" or "comma" formation during brass polishing and sulfur absorption by nickel during glowing.—PDA. 6647

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8.9.1, 6.4.2

Today's Aluminum Aircraft Alloys. J. A. Nock. Aluminum Co. of American. Paper before SAE Nat. Aeronautic Mtg., L. A., Oct. 3, 1952. *SAE J.*, **61,** No. 3, 65-67 (1953) Mar.

Recent additions to aircraft aluminum alloys include alloys XF18S and XA19S which are strong materials at high temperatures, higher strength structural alloy XA78S which is a higher strength 75S-type alloy, thinner and stronger cladding and aircraft rivets of 75S-T6 with higher shear strength than 24S rivets. Properties are discussed. 75S rivets with satisfactory resistance to stress-corrosion cracking were developed —but at a sacrifice in shearing strength. A comparison of tensile properties of XF18S and XA19S with those of 18S, B18S and 14S alloys at room and elevated temperatures and properties of aluminum alloys and aluminum powder products [APMP (aluminum powder metallurgy products), 18S-T61 and XA19S-T6] are tabulated.—INCO. 6372

8.9.2, 4.6.4, 5.8.2, 4.4.3, 7.1

Sodium Benzoate and Sodium Nitrite as Corrosion-Inhibitors in Ethylene Glycol Anti-Freeze Solutions. Part II. Investigations in Working Vehicles. F. Wormwell, A. D. Mercer, and H. C. K. Ison. *J. Applied Chem.* (London), **3,** Pt. 3, 133-144 (1953) March.

Sixty tests were carried out in working vehicles to establish the efficiency of the benzoate/nitrite corrosion-inhibitor in service conditions. The testing technique and the method of assessment of results are described. Of special importance is the need to carry out parallel tests in several vehicles, because of the varying rates of corrosion in different vehicles carrying the same coolant. Tests showed that the addition of 1.5% sodium benzoate with 0.1% sodium nitrite to 20 or 33⅓% solutions of ethylene glycol will effectively prevent corrosion of the cast iron of the cylinder block or head in the usual engine system. Corrosion of the radiator unit will also be prevented. The benzoate/nitrite inhibitor does not always prevent the corrosion of aluminum alloys. Tables, graphs and photographs.—INCO. 6528

8.9.3, 1.3, 5.4.10, 5.4.5

Comparison of Plastic Tape and Hot Enamels for Protective Coatings of Pipe. N. P. Peifer. *Gas Age,* **111,** 41-43, 98, 100 (1953) May 21.

Presents cost facts and figures for protection of typical lines by anodes, mill coated pipe, plastic tape and over-the-ditch coated pipe. Provides details on test procedures used.—BTR. 6446

8.9.3, 8.4.2, 5.11

Economics of Corrosion Control for Gas Distribution Systems. A. W. Peabody. Ebasco Services Inc. Paper before AGA Convention, 1952. *Gas,* **29,** No. 1, 51-53, 58 (1953) Jan.

Discussion of the facts that it is now possible to design for essentially corrosion-free systems and that the most economical time to design for corrosion prevention is while planning the basic installation. When planning distribution mains, design factors involved in adequate corrosion performance include proper use of materials, use of coatings, freedom from electrical contact with foreign structures and use of cathodic protection. Bare vs. coated, hot spot protection and compression-type fittings are investigated. Photographs.—INCO. 6438

8.9.3

How to Combat Pipe-Line Corrosion. *Oil Gas J.*, **52,** No. 12, 363 (1953) July 27.

Protective coatings such as metallic, concrete, grease, mastic and bituminous coatings used in combating pipeline corrosion are evaluated.—INCO. 6383

8.9.2, 6.4.4

Automotive Service Experience with Magnesium. F. H. Mason. Chrysler Corp. Paper before Magnesium Assn., 8th Ann. Mtg. *Modern Metals,* **9,** No. 1, 34, 36 (1953) Feb.

Discussion of service experience with magnesium which was used in various automotive parts. Results after three years of service indicate that corrosion of magnesium by road salts is not severe enough to restrict its application. Service data on parts exposed to corrosive fluids indicated that magnesium could not be used without protective chemical treatment or coatings. There was no undesirable corrosion in painted magnesium castings used in parts such as steering column shrouds, etc., after two years production service. Stress, fatigue and machining factors are discussed. Illustrations.—INCO. 6380

8.9.2, 4.4.3, 6.2.2, 6.3.6, 5.8.2

Sodium Benzoate and Sodium Nitrite as Corrosion-Inhibitors in Ethylene Glycol Anti-Freeze Solutions. Part I. Laboratory Investigations (of Brass and Cast Iron). F. Wormwell and A. D. Mercer. *J. Applied Chem.* (London), **3,** Pt. 1, 22-27 (1953).

The corrosion of cast iron and of soldered brass strips in ethylene glycol solution containing sodium benzoate and/or sodium nitrite was studied under conditions simulating the temperature changes in engine-cooling systems, copper specimens being included in one series of tests. Sodium nitrite efficiently inhibited corrosion of cast iron under the conditions stated, but in concentrations $\geqslant 0.1\%$ greatly accelerated corrosive attack on the soldered brass, the corrosion increasing with increasing sodium nitrite content. Corrosion of cast iron, soldered joints, brass, and copper in 20% ethylene glycol containing 0.1% sodium nitrite was, however, simultaneously inhibited by the addition of 1.5% of sodium benzoate.—MA. 6527

8.9.4

"Crusader" Checked for Corrosion. *Ry. Age,* **134,** No. 25, 17-18 (1953) June 22.

During 1952, Reading stripped its stainless steel "Crusader" of the interior finish and the exterior sheathing for an examination of the frame structures. The frames which went into service in 1937 were free from corrosion. In the kitchen the bottom of the carbon steel partition between the kitchen, pantry and hallway was corroded due to leaks in the ice-cream box which released salt-laden moisture. Considerable corrosion of aluminum window sashes was found where they were covered on the outside with stainless steel strips. The cause was diagnosed as electrolytic action set up by salts from cleaning solutions which accumulated between the stainless steel and the aluminum. The sashes were treated to passivate the metal.—INCO. 6556

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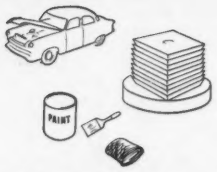

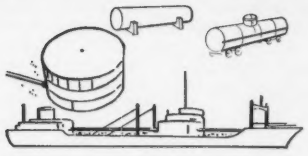

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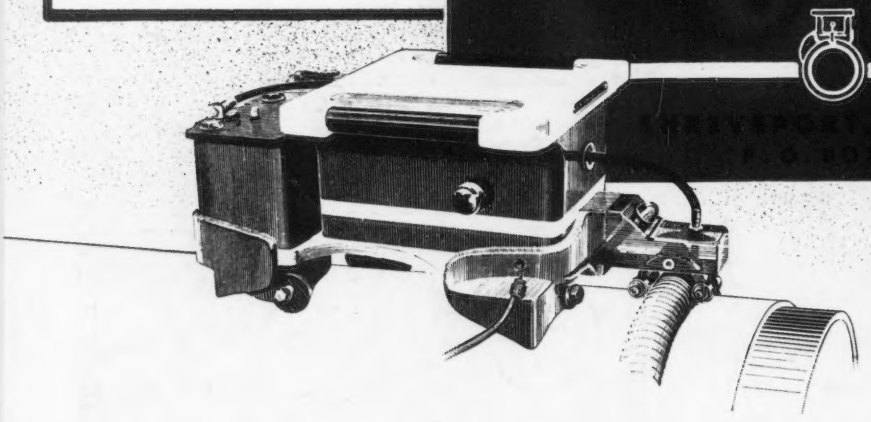

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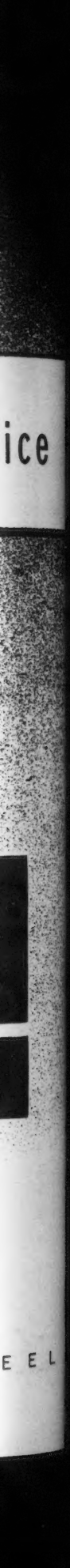
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